Motion Control

7350 Hardware User Manual

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About This Manual

This manual describes the electrical and mechanical aspects of the NI-7350 motion controller and contains information concerning its installation and operation.

The 7350 controller is designed for PXI bus computers.

Refer to the *Glossary* for definitions of selected related terms.

Conventions

This manual uses the following conventions:

<> — Angle brackets that contain numbers separated by an ellipsis represent a range of values associated with a bit or signal name—for example, DIOB<3..0>.

» — The » symbol leads you through nested menu items and dialog box options to a final action. The sequence **File»Page Setup»Options** directs you to pull down the **File** menu, select the **Page Setup** item, and select **Options** from the last dialog box.

This icon denotes a tip, which alerts you to advisory information.

This icon denotes a note, which alerts you to important information.

This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash.

bold — Bold text denotes items that you must select or click in the software, such as menu items and dialog box options. Bold text also denotes parameter names.

italic — Italic text denotes variables, emphasis, a cross reference, or an introduction to a key concept. This font also denotes text that is a placeholder for a word or value that you must supply.

`monospace` — Text in this font denotes text or characters that you should enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames and extensions, and code excerpts.

Related Documentation

The following documents contain information you might find helpful as you read this manual:

- *NI-Motion C Reference Help*
- *NI-Motion VI Reference Help*
- *NI-Motion User Manual*
- *Getting Started With NI-Motion*
- *PXI Specification*, Revision 2
- The technical reference manual for the computer you are using

1

Introduction

This chapter describes the NI PXI-7350 motion controller and its operation.

About the 7350 Controller

The PXI-7350 motion controller features advanced motion control with easy-to-use software tools and add-on motion VI libraries for use with LabVIEW.

Features

The 7350 motion controller is a combination servo and stepper motor controller for PXI bus computers. It provides fully-programmable motion control for up to eight independent axes of motion. Coordinated motion is supported through multi-dimensional coordinate spaces. Each axis provides dedicated motion I/O for limit and home switches and additional I/O for general-purpose functions.

You can use the 7350 motion controller for point-to-point and straight-line vector moves. The 7350 also performs arbitrary and complex motion trajectories through circular interpolation and contouring.

Servo axes can control DC brushed or brushless servo motors, servo hydraulics, servo valves, and other servo devices, such as closed-loop piezo motor systems. Servo axes always operate in closed-loop mode. These axes use quadrature encoders or analog inputs for position and velocity feedback and provide analog command outputs with an industry-standard range of ±10 V.

Stepper axes control stepper motors in either open or closed-loop mode. They use quadrature encoders or analog inputs for position feedback (closed-loop only), and provide step/direction or clockwise (CW) /counter-clockwise (CCW) digital command outputs. All stepper axes support full, half, and microstepping applications.

Hardware

The 7350 controller has high-performance capabilities due to its advanced dual-processor architecture for embedded real-time control. This powerful functionality provides high-speed communications while off-loading complex motion functions from the host PC for maximum command throughput and system performance.

The 7350 features motion profiles that are controlled with enhanced *PID*/*PIVff* high-speed servo update rates. The update rate depends on the number of axes enabled. Refer to Appendix A, *Specifications*, for more information.

Each axis has motion I/O for end-of-travel limit and home switch inputs, breakpoint output, trigger input, hall effect sensor input, and encoder feedback. The 7350 controller also has non-dedicated user I/O including 64 bits of digital I/O and eight analog inputs for ±10 V signals, joystick inputs, or analog sensor monitoring. Additionally, the 7350 analog inputs can provide feedback for loop closure.

RTSI

The 7350 controller supports the National Instruments Real-Time System Integration (RTSI) bus. The RTSI bus provides high-speed connectivity between National Instruments products, including image acquisition (IMAQ) and data acquisition (DAQ) products. Using the RTSI bus, you can easily synchronize several functions to a common trigger or timing event across multiple motion, IMAQ, or DAQ devices.

What You Need to Get Started

To set up and use the 7350 controller, you must have the following items:

- ❑ NI PXI-7350 motion controller
- ❑ *7350 Hardware User Manual*
- ❑ NI-Motion 6.0 or later driver software and documentation
- ❑ One of the following software packages and documentation:
  - LabVIEW 6.0 or later
  - LabWindows™/CVI™
  - Measurement Studio

  - C/C++
  - Microsoft Visual Basic

- ❑ A PXI chassis with an available PXI slot

Software Programming Choices

The PXI-7350 motion controller comes with a simple but powerful high-level function set application programming interface (API) that makes it easy to program. You can execute all setup and motion control functions by calling into a dynamically-linked library (DLL). You can use the full function set implementations for LabVIEW, LabWindows/CVI, and other industry-standard software programs, or call the NI-Motion libraries from C, Visual Basic, and other high-level languages.

National Instruments Application Software

LabVIEW is based on the graphical programming language G and features interactive graphics and a state-of-the-art user interface. In LabVIEW, you can create 32-bit compiled programs and stand-alone executables for custom automation, data acquisition, test, measurement, and control solutions. National Instruments offers the NI-Motion VI Library, a series of virtual instruments (VIs) for using LabVIEW with National Instruments motion control hardware. The NI-Motion VI library implements the full API, along with a useful set of example programs.

ANSI C-based LabWindows/CVI also features interactive graphics and a state-of-the-art user interface. Using LabWindows/CVI, you can generate C code for custom data acquisition, test, measurement, and automation solutions. The NI-Motion software includes a series of example programs for using LabWindows/CVI with National Instruments motion control hardware.

NI Motion Assistant offers a point-and-click interface for creating motion control sequences quickly and easily. When you have created your motion task, Motion Assistant outputs the task in LabVIEW code or code recipes.

Optional Equipment

National Instruments offers a variety of products for use with the 7350 controller, including the following accessories:

- Cables and cable assemblies for motion and digital I/O
- Universal Motion Interface (UMI) wiring connectivity blocks with integrated motion signal conditioning and motion inhibit functionality
- Stepper and servo motor compatible drive amplifier units with integrated power supply and wiring connectivity
- Connector blocks and shielded and unshielded 68-pin screw terminal wiring aids

For more specific information about these products, refer to the National Instruments catalog, the National Instruments Web site at `ni.com`, or call your National Instruments sales representative.

Motion I/O Connections

The external motion and digital I/O connectors on the 7350 controller are high-density, 68-pin female VHDCI connectors.

For custom cables, use the AMP mating connector (part number 787801-01).

2

Configuration and Installation

This chapter describes how to configure and install the 7350 controller.

Software Installation

Before installing the 7350 controller, install the NI-Motion software and, if appropriate, the NI-Motion VI libraries. Refer to the release notes included with the controller for specific instructions on the software installation sequence for your host PC.

Controller Configuration

Because the motion I/O-related configuration of 7350 controller is performed entirely with software, it is not necessary to set jumpers for motion I/O configuration.

The 7350 controller is fully compatible with the *PXI Specification*, Revision 2.0. This compatibility allows you to configure the computer to automatically perform all bus-related configuration without user interaction. It is not necessary to configure jumpers for bus-related configuration.

Note When adding or removing a controller from a Windows XP/NT/2000 system, you must be logged on with administrator-level access. After you have restarted your system, you may need to refresh MAX to view your new controller.

Safety Information

Caution The following section contains important safety information you *must* follow when installing and operating the device.

Do *not* operate the device in a manner not specified in the documentation. Misuse of the device may result in a hazard and may compromise the safety protection built into the device. If the device is damaged, turn it off and do

not use it until service-trained personnel can check its safety. If necessary, return the device to National Instruments for repair.

Keep away from live circuits. Do *not* remove equipment covers or shields unless you are trained to do so. If signal wires are connected to the device, hazardous voltages can exist even when the equipment is turned off. To avoid a shock hazard, do *not* perform procedures involving cover or shield removal unless you are qualified to do so. Disconnect all field power prior to removing covers or shields.

If the device is rated for use with hazardous voltages (>30 V_{rms}, 42.4 V_{pk}, or 60 V_{dc}), it may require a safety earth-ground connection wire. Refer to the device specifications for maximum voltage ratings.

Because of the danger of introducing additional hazards, do *not* install unauthorized parts or modify the device. Use the device only with the chassis, modules, accessories, and cables specified in the installation instructions. All covers and filler panels must be installed while operating the device.

Do *not* operate the device in an explosive atmosphere or where flammable gases or fumes may be present. Operate the device only at or below the pollution degree stated in the specifications. Pollution consists of any foreign matter—solid, liquid, or gas—that may reduce dielectric strength or surface resistivity. The following is a description of pollution degrees:

- Pollution Degree 1—No pollution or only dry, nonconductive pollution occurs. The pollution has no effect.
- Pollution Degree 2—Normally only nonconductive pollution occurs. Occasionally, nonconductive pollution becomes conductive because of condensation.
- Pollution Degree 3—Conductive pollution or dry, nonconductive pollution occurs. Nonconductive pollution becomes conductive because of condensation.

Clean the device and accessories by brushing off light dust with a soft, nonmetallic brush. Remove other contaminants with a stiff, nonmetallic brush. The unit *must* be completely dry and free from contaminants before returning it to service.

You *must* insulate signal connections for the maximum voltage for which the device is rated. Do *not* exceed the maximum ratings for the device. Remove power from signal lines before connection to or disconnection from the device.

Operate this device only at or below the installation category stated in the specifications. The following is a description of installation categories:

- Installation Category IV—For measurements performed at the source of the low-voltage (<1000 V) installation. Examples include electricity meters, measurements on primary overcurrent protection devices, and ripple-control units.
- Installation Category III—For measurements performed in the building installation. Examples include measurements on distribution boards, circuit-breakers, wiring (including cables), bus bars, junction boxes, switches, socket outlets in the fixed installation, equipment for industrial use, and some other types of equipment, such as stationary motors permanently connected to the fixed installation.
- Installation Category II—For measurements performed on circuits directly connected to the low-voltage installation. Examples include measurements on household appliances, portable tools, and other similar equipment.
- Installation Category I—For measurements performed on circuits not directly connected to MAINS[1]. Examples include measurements on circuits not derived from mains, and specially-protected (internal) MAINS-derived circuits.

Figure 2-1 illustrates a sample installation.

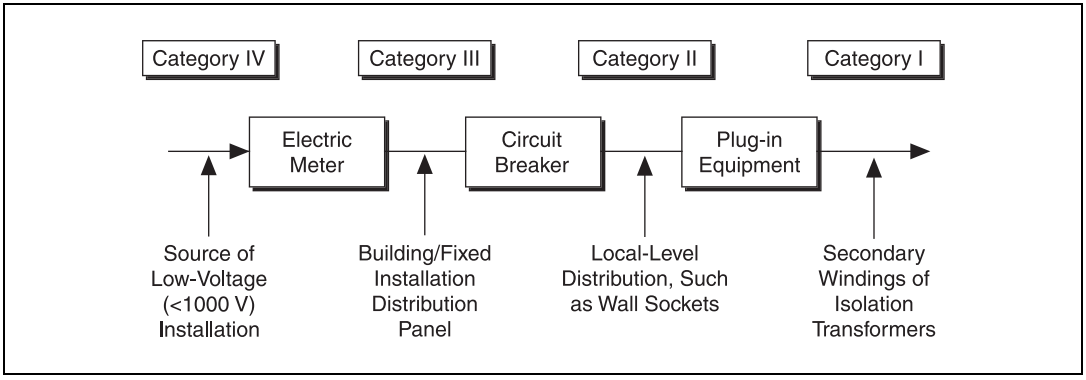


Figure 2-1. Sample Installation

[1] *MAINS* is defined as the electricity supply system to which the equipment concerned is designed to be connected for either powering the equipment or for measurement purposes.

Hardware Installation

You can install the 7350 controller in any open compatible expansion slot in your PXI chassis. Appendix A, *Specifications*, lists the maximum power required for the 7350 controller.

The following instructions are for general installation. Consult your PXI chassis user manual or technical reference manual for specific instructions and warnings.

Caution The 7350 controller is a sensitive electronic device shipped in an antistatic bag. Open only at an approved workstation and observe precautions for handling electrostatic-sensitive devices.

1. Power off and unplug your chassis.
2. Remove the filler panel from a +3.3 V or +5 V peripheral slot.
3. Touch a metal part on your chassis to discharge any static electricity that might be on your clothes or body.
4. Insert the PXI controller into the slot. Use the injector/ejector handle to fully inject the device into place.
5. Screw the front panel of the PXI board to the front panel mounting rails of the chassis.
6. Visually verify the installation.
7. Plug in and power on the chassis.

The 7350 controller is installed.

Caution Make sure you have correctly connected all safety devices before you power on your motion system. Safety devices include inhibits, limit switches, and emergency shut down circuits.

Caution Always power on the 7350 controller before you power on the rest of your motion system. Power off in the reverse order, leaving the 7350 controller until last.

Note When adding or removing a controller from a Windows XP/NT/2000 system, you must be logged on with administrator-level access. After you have restarted your system, you may need to refresh MAX to view your new controller.

Connecting Brushless Servo Motors

The 7350 motion controller can connect to brushless servo drives that perform sinusoidal commutation or to drives that do not. When connecting to a drive that performs the sinusoidal commutation, only one DAC output is required per axis. For information about configuring the NI-Motion software to work with this type of system, refer to the *MAX for Motion Online Help*.

When connected to a drive that does not perform the sinusoidal commutation, the 7350 commutates the first two phases and the servo drive determines the third. Therefore, two DAC outputs are required per axis. By default, NI-Motion maps the DAC outputs to the axes shown in Table 2-1.

Table 2-1. Axis to DAC Outputs Mapping

Axis	DAC Outputs
1	1, 3
2	2, 4
3	5, 7
4	6, 8

Connecting the Hall Effect Sensors

Before the 7350 can calculate the commutation values, some form of initialization is necessary to determine the initial commutation phase angle of the brushless motor each time the motion controller is powered on, reset, or reconfigured.

One method of initialization is to connect Hall effect sensors to detect the commutation phase angle of the motor. You can specify how your system is configured in Measurement & Automation Explorer (MAX).

Tip If you do not connect Hall effect sensors, you can set the commutation phase angle directly, or through a process called *shake and wake*. Shake and wake requires moving your motors to the 0º angle and setting the commutation phase angle to match.

It is important to correctly connect the Hall effect sensors to the motion controller so that the sensors accurately determine the commutation phase angle. Complete the following steps to connect your Hall effect sensors.

1. Locate the Hall effect sensor phase sequence diagram that applies to the motor you are using. The manufacturer of the motor should provide this diagram with the motor documentation.

Note The 7350 motion controller can use Hall effect sensors having three sensor outputs per motor. Each output is 120 degrees out of phase from the previous output.

2. Wire the Hall sensors based on the Hall effect sensor phase sequence diagram for the motor and Figures 2-2 and 2-3.

   Match the Hall effect sensor phase sequence diagram for the motor with one of the diagrams below. The diagrams on the left represent the diagram supplied with the motor. The diagrams on the right represent the expected inputs to the UMI or 7350. The arrows in the middle show the correct path to wire the Hall effect sensor outputs into the UMI or 7350 inputs.

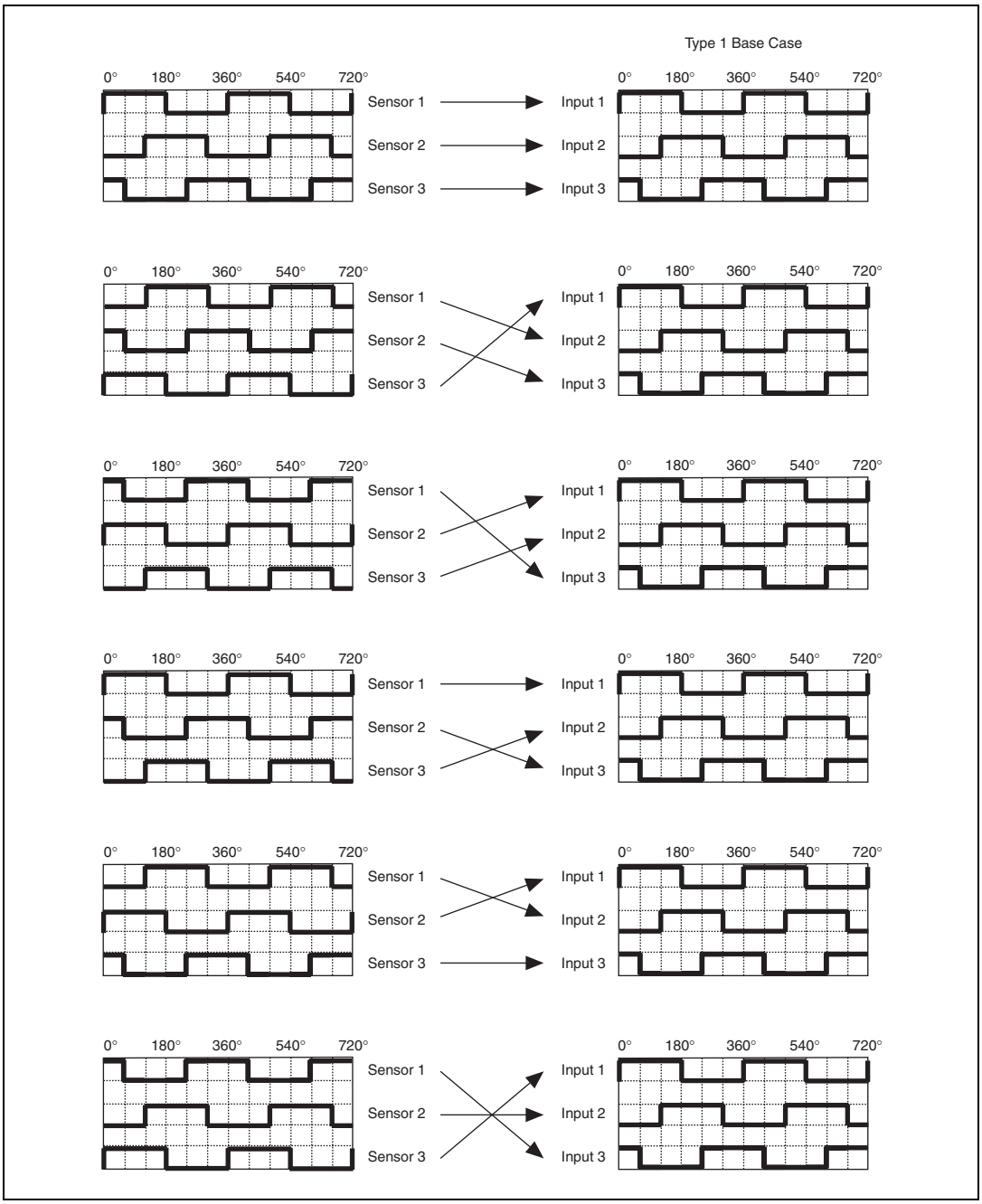


Figure 2-2. Type 1 Hall Sensor Wiring Diagrams

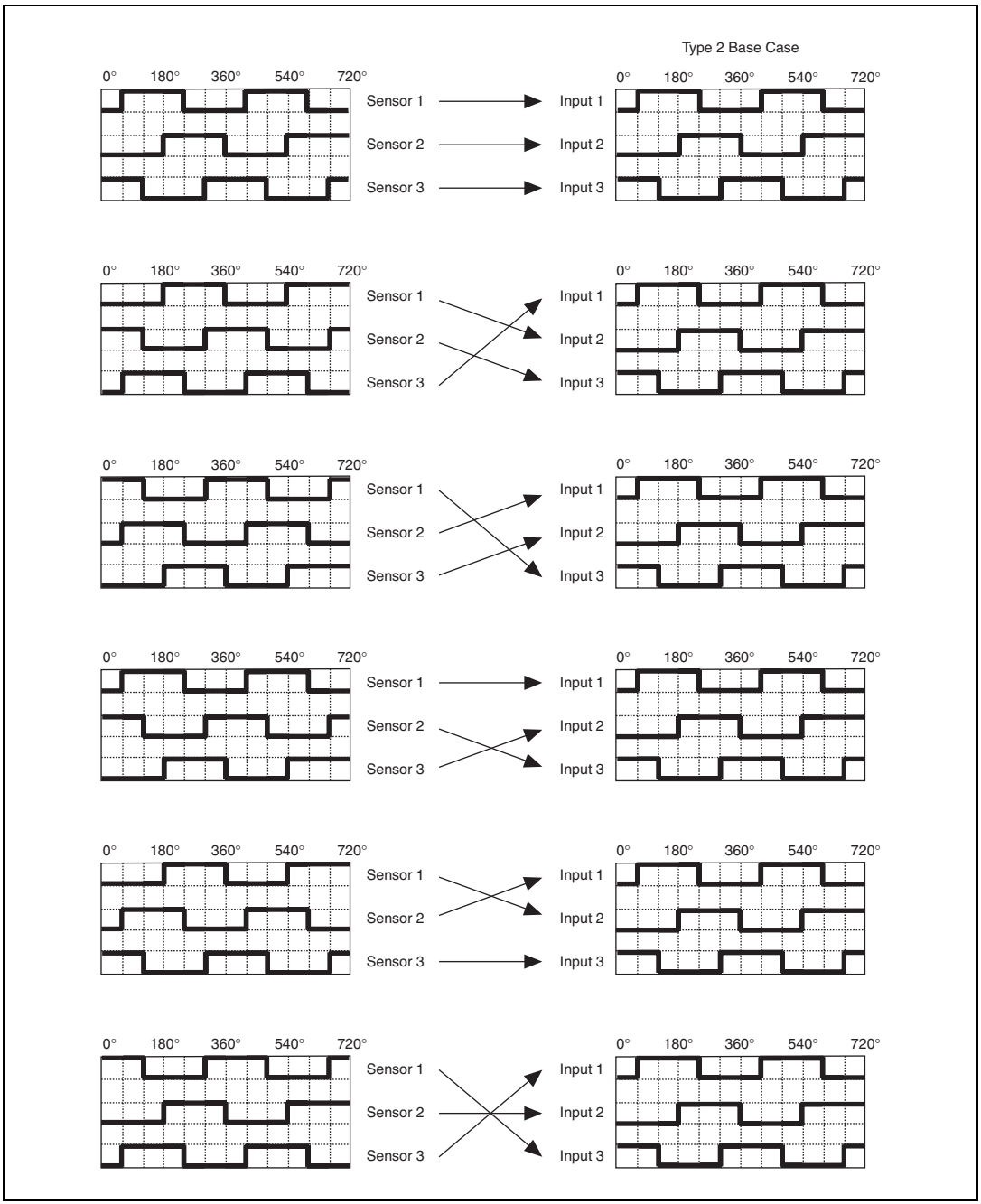


Figure 2-3. Type 2 Hall Sensor Wiring Diagrams

For example, if the diagram supplied with your motor matches the third Type 2 diagram, you wire Hall effect sensor 1 to input 3 on the UMI or 7350, and then wire sensor 2 to input 1 and sensor 3 to input 2.

The Hall effect sensor inputs for Axes 1–4 are defined as follows:

- Axis 1 uses digital port 4, bits 2–4, with bit 2 as input 1.
- Axis 2 uses digital port 4, bits 5–7, with bit 5 as input 1.
- Axis 3 uses digital port 8, bits 2–4, with bit 2 as input 1.
- Axis 4 uses digital port 8, bits 5–7, with bit 5 as input 1.

Refer to Figure 5-6, *68-Pin Digital I/O Connector Pin Assignments (Ports 1–4)*, and Figure 5-7, *68-Pin Digital I/O Connector Pin Assignments (Ports 5–8)*, for a detailed pinout of the digital I/O connectors.

3. Configure your system in MAX. There are two base types of Hall effect sensor inputs. Set the NI-Motion software to the base sensor type you are using.

   If the motor documentation matches any of the patterns in Figure 2-2, you are using Type 1 and match the following graph.

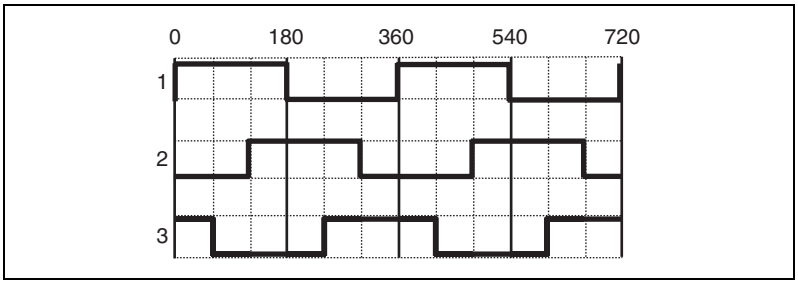


Figure 2-4. Type 1 Hall Sensor Phasing Sequence Diagram

If the motor documentation matches any of the patterns in Figure 2-3, you are using Type 2 and match the following graph.

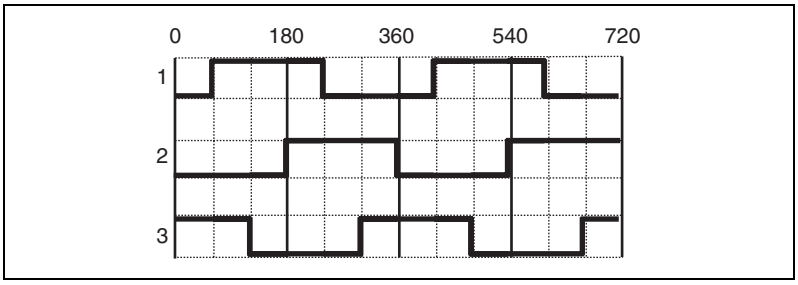


Figure 2-5. Type 2 Hall Sensor Phasing Sequence Diagram

Refer to MAX for information about configuring the NI-Motion software for brushless servo motors.

Connecting the Motor Leads

For your brushless motor to generate maximum torque, the motion system must output the commutation on the three motor phases correctly. Two of the phases are controlled by the 7350 motion controller, and the third phase is generated by the drive.

The primary output of the 7350 wires into the primary input of your drive. The secondary output wires into the secondary input of the drive. Set the primary and secondary outputs of your NI-7350 using MAX.

When you wire the brushless motor to the drive, use the commutation diagram for your motor as a reference. The manufacturer of the motor typically provides this diagram with the motor documentation.
The commutation diagram shows the expected value on each of the motor leads at each angle in the commutation phase, typically in 60-degree increments. Table 2-2 shows an example of a motor phasing commutation diagram, and Figure 2-6 shows the corresponding graphical representation.

Table 2-2. Motor Phasing Diagram

Motor Lead	0º	60º	120º	180º	240º	300º
A	+	+	NC	–	–	NC
B	–	NC	+	+	NC	–
C	NC	–	–	NC	+	+

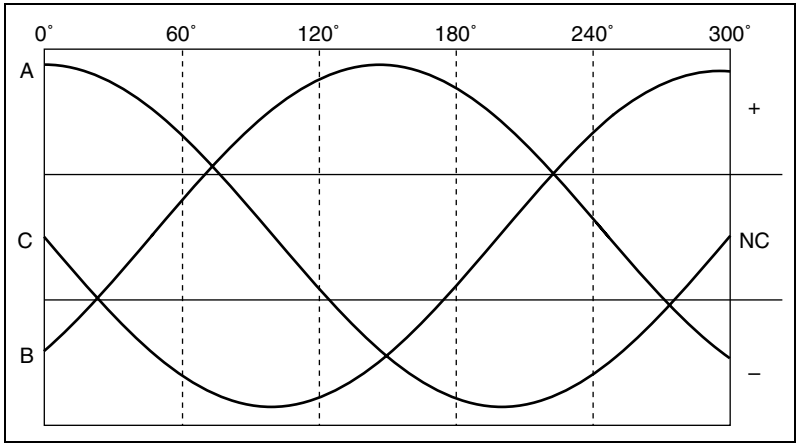


Figure 2-6. Sine Wave Motor Phasing Diagram

Table 2-3 shows the correct method of wiring a brushless motor to the drive.

Table 2-3. Correct Wiring Diagram At 0º Commutation Phase

Drive Motor Output	Brushless Motor Lead State*
1	No Current (NC)
2	Positive Current
3	Negative Current
* At 0º commutation phase	

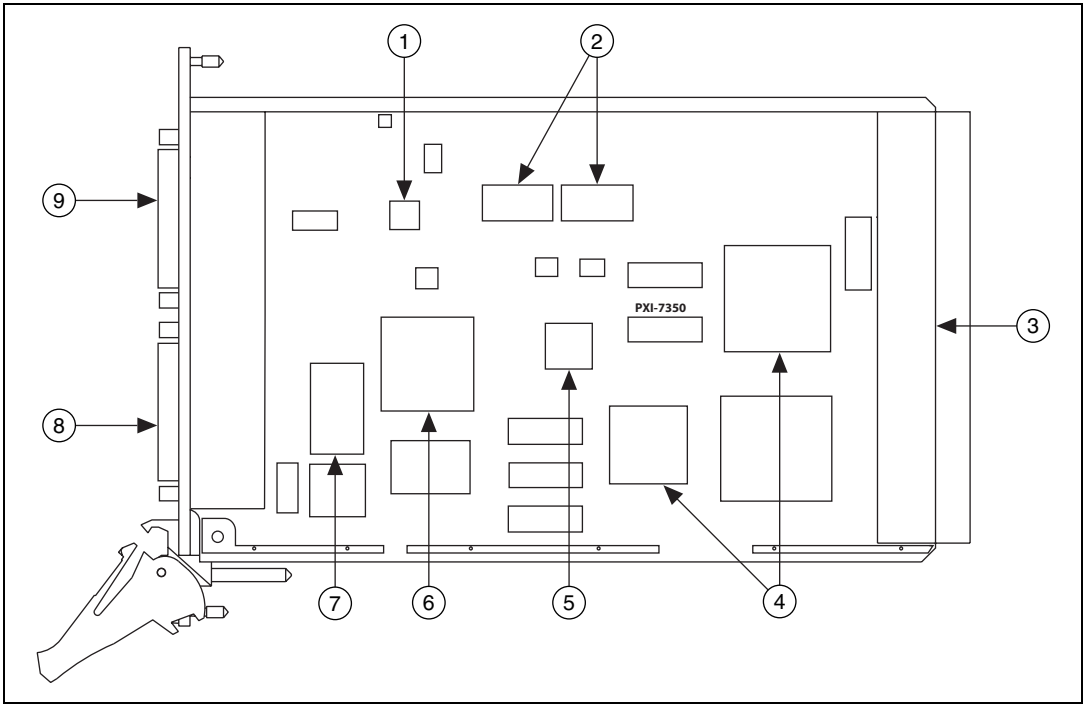
For example, if your motor has the phasing characteristics described in Table 2-2, wire the motor lead C to the motor output 1 on the drive. You wire the lead this way because the motor lead C calls for No Current at 0º Commutation Phase, and drive motor output 1 matches the No Current requirement. Similarly, wire motor lead A to motor output 2 and motor lead B to motor output 3 on the drive.

3

Hardware Overview

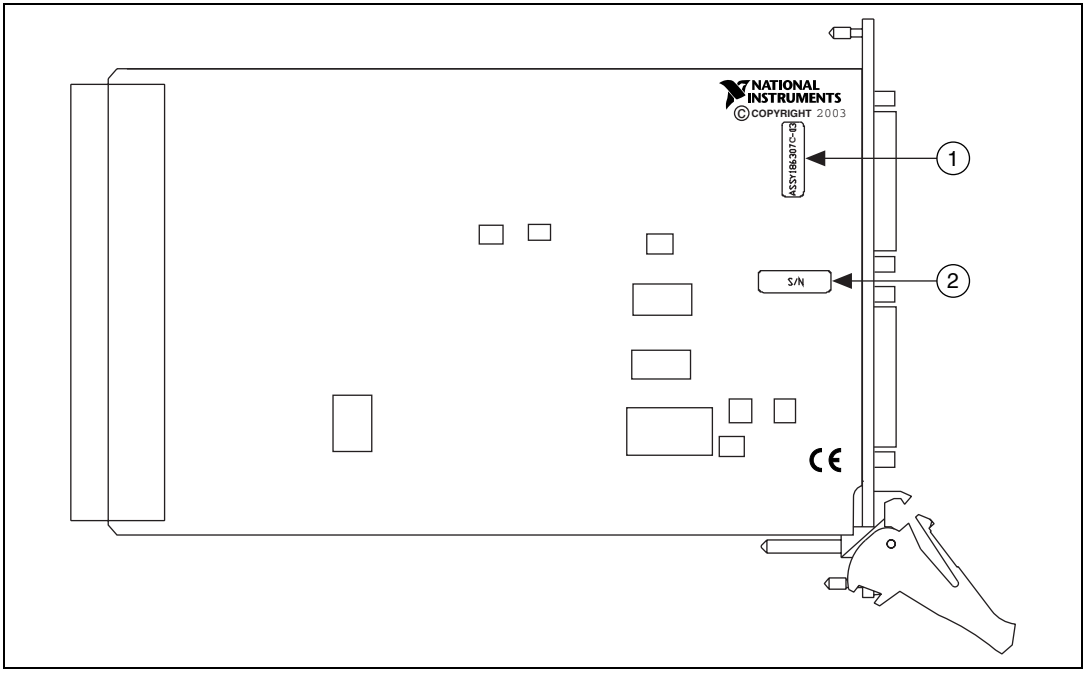
This chapter presents an overview of the 7350 controller hardware functionality.

Figures 3-1 and 3-2 show the 7350 parts locator diagrams.



1	16-bit ADC	6	32-bit CPU
2	16-bit DACs	7	Nonvolatile FLASH Memory
3	RTSI and PXI Bus Connector	8	68-pin Digital I/O Connectors
4	Field-Programmable Gate Arrays	9	68-pin Motion I/O Connectors
5	DSP		

Figure 3-1. PXI-7350 Parts Locator Diagram (Front Panel)



1 Assembly Number	2 Serial Number Label

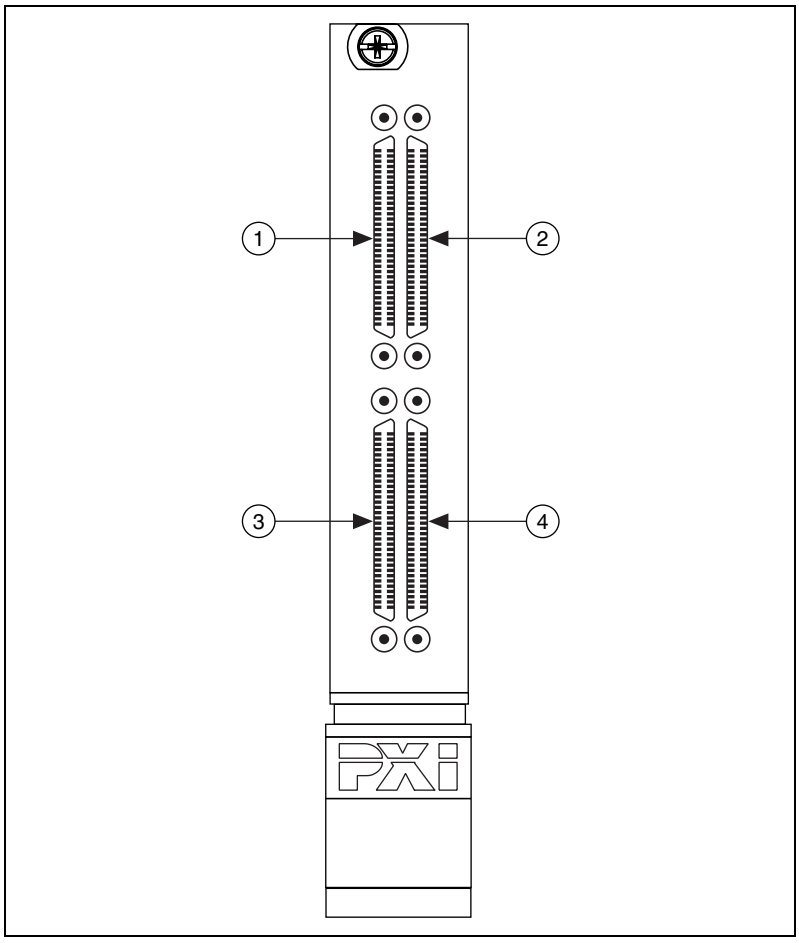
Figure 3-2. PXI-7350 Parts Locator Diagram (Back Panel)

User Connectors

The two 68-pin motion I/O connectors provide all the signals for up to eight axes of closed-loop motion control, including encoder feedback, limit and home inputs, breakpoint outputs, trigger inputs, and analog-to-digital (A/D) converter signals. Refer to Chapter 5, *Signal Connections*, for details about the signals in the motion I/O connectors.

The two 68-pin digital I/O connectors provide 64 bits of user-configurable digital I/O, including 12 inputs for 4 Hall effect sensors. Refer to Chapter 5, *Signal Connections*, for details about the signals in the digital I/O connectors.

Figure 3-3 shows the four 68-pin I/O connectors on the 7350 motion controller.



1	Motion I/O Connector (Axes 1–4)	3	Digital I/O Connector (Ports 1–4)
2	Motion I/O Connector (Axes 5–8)	4	Digital I/O Connector (Ports 5–8)

Figure 3-3. 7350 68-pin Connectors

The RTSI-enabled PXI connection provides up to eight triggers and one PXI star trigger to facilitate synchronization between multiple National Instruments PXI-enabled products. Typical applications of the RTSI bus include triggering an image aquisition or DAQ measurement based on motion events, or capturing current motion positions based on events external to the motion controller. You also can use the RTSI bus for general hardware-based communication between RTSI devices.

4

Functional Overview

This chapter provides an overview of the 7350 motion controller architecture and its capabilities.

Dual Processor Architecture

The 7350 controller can perform up to eight axes of simultaneous motion control in a preemptive, multitasking, real-time environment.

An advanced dual-processor architecture, 32-bit CPU, digital signal processor (DSP) for embedded real-time control, and custom FPGAs give the 7350 controller high-performance capabilities. The powerful function set provides high-speed communications while off-loading complex motion functions from the host PC for optimized system performance.

The 7350 controller uses the DSP for all closed-loop control, including position tracking, PID control closed-loop computation, and motion trajectory generation. The DSP chip is supported by a custom FPGA that performs the high-speed encoder interfacing, position capture and breakpoint functions, motion I/O processing, and stepper pulse generation for hard real-time functionality.

The embedded CPU runs a multitasking real-time operating system and handles host communications, command processing, multi-axis interpolation, onboard program execution, error handling, general-purpose digital I/O, and overall motion system integration functions.

Embedded Real-Time Operating System (RTOS)

The embedded firmware is based upon an embedded RTOS kernel and provides optimum system performance in varying motion applications. Motion tasks are prioritized. Task execution order depends on the priority of each task, the state of the entire motion system, I/O or other system events, and the real-time clock.

The DSP chip is a separate processor that operates independently from the CPU but is closely synchronized through interprocessor

communication. The 7350 is a true multiprocessing and multitasking embedded controller.

The architecture of the 7350 controller enables advanced motion features, such as enhanced PID functions. Refer to the *NI-Motion User Manual* for more information about using the features available on the 7350 controller.

Trajectory Generators

The controller trajectory generators on the 7350 calculate the instantaneous position command that controls acceleration and velocity while it moves the axis to its target position. Depending on how you configure the axis, this command is then sent to the PID servo loop or stepper pulse generator.

To implement infinite trajectory control, the 7350 controller has 16 trajectory generators implemented in the DSP chip (two per axis). Each generator calculates an instantaneous position each PID update period. While simple point-to-point moves require only one trajectory generator, two simultaneous generators are required for blended moves and infinite trajectory control processing.

Analog Input and Output

The 7350 controller has an 8-channel multiplexed, 16-bit ADC. The converted analog values are broadcast to both the DSP and CPU via a dedicated internal high-speed serial bus. The multiplexer scan rate provides high sampling rates required for feedback loop closure, joystick inputs, or monitoring analog sensors.

For analog output, the 7350 uses two four-channel 16-bit DACs that are updated each PID loop.

Both the analog input and output circuitry are calibrated at the factory for excellent accuracy and performance. For applications requiring even higher analog accuracy, you can recalibrate the 7350 analog input and output circuitry in the field using a self-calibration routine included in MAX.

Onboard Sinusoidal Commutation

The 7350 controller provides onboard sinusoidal commutation for axes controlling brushless DC servo motors. This feature reduces overall system cost by allowing you to use less complex, and therefore less expensive, motor drives.

Flash Memory

Nonvolatile memory on the 7350 controller is implemented with flash ROM, which means the controller can electrically erase and reprogram its own ROM. Because all of the embedded firmware, including the RTOS and DSP code, of the 7350 is stored in flash memory, you can upgrade the onboard firmware contents in the field for support and new-feature enhancement.

Flash memory also allows objects, such as programs and data arrays, to be stored in non-volatile memory.

It is possible to save the entire configuration state of the controller to the flash memory. On the next power cycle, the controller automatically loads and returns the configuration to these new saved default values.

Use MAX, which is included with the NI-Motion driver software, to download new firmware or save configuration defaults to flash memory.

Axes and Motion Resources

The 7350 controller can control up to eight axes of motion that can be completely independent, simultaneously started, or mapped in multidimensional groups called coordinate spaces. You also can simultaneously start coordinate spaces for multi-vector space coordinated motion control.

Axes

At a minimum, an axis consists of a trajectory generator, a PID (for servo axes) or stepper control block, and at least one output resource—either a DAC output (for servo axes) or a stepper pulse generator output. Servo axes must also have either an encoder or ADC channel feedback resource. In addition to an encoder feedback, brushless DC servo axes can also use Hall effect sensors for initial position feedback. Closed-loop stepper axes also require a feedback resource, while open-loop stepper axes do not. Figures 4-1 and 4-2 show these axis configurations.

With the 7350 controller, you can map one or two feedback resources and one or two output resources to the axis.

A stepper axis has its primary output resource mapped to a stepper output. A servo axis has its primary output resource mapped to a DAC.

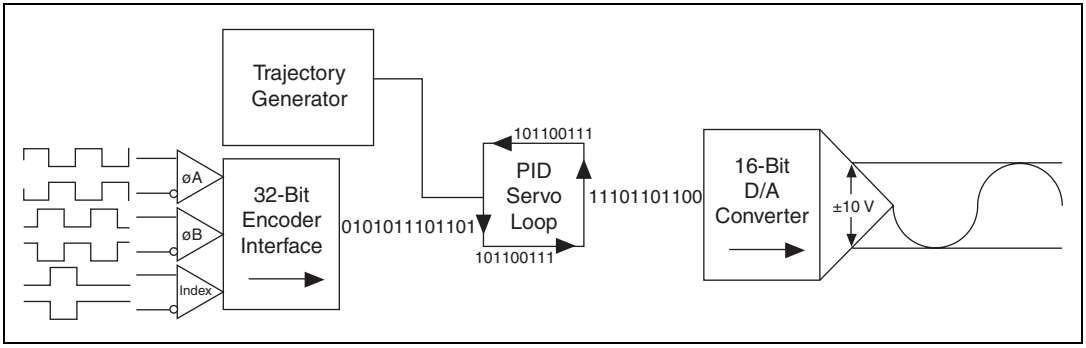


Figure 4-1. Servo Axis Resources

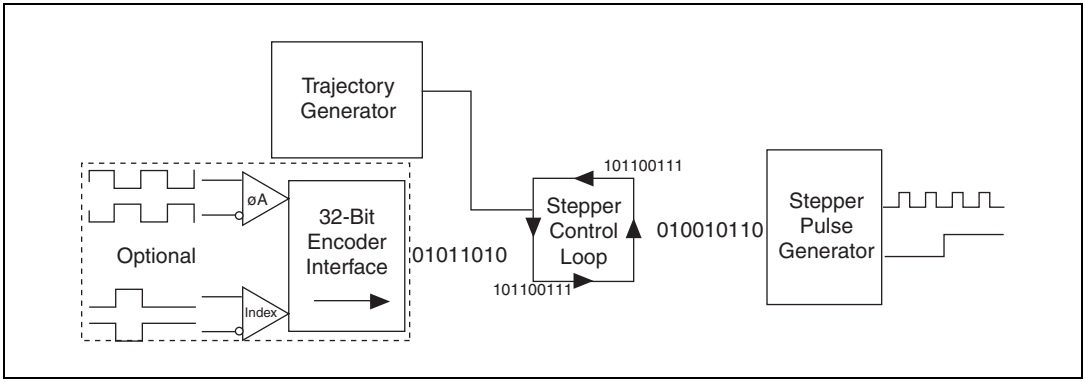


Figure 4-2. Stepper Axis Resources

The 7350 controller supports axes with secondary output resources. Defining two output resources is useful when controlling axes with multiple motors, such as gantry systems in which two DAC outputs can be configured with different torque limits and/or offsets. The 7350 controller also can use two DAC output resources when controlling a brushless DC servo axis for sinusoidal commutation.

The 7350 controller also supports secondary feedback resources (encoders) for axes defined as servo. Two feedback resources are used when implementing dual-loop control (such as in backlash compensation), which reduces the number of encoders available for other axes.

Note Refer to the *NI-Motion User Manual* for more information about configuring axes.

Motion Resources

Encoder, DAC, ADC, and motion I/O resources that are not used by an axis are available for non-axis or non-motion-specific applications. You can directly control an unmapped DAC as a general-purpose analog output (±10 V). Similarly, you can use any ADC channel to measure potentiometers or other analog sensors.

If an encoder resource is not needed for axis control, you can use it for any number of other functions, including position monitoring, as a digital potentiometer encoder input, or as a master encoder input for master/slave (electronic gearing) applications.

Each axis also has an associated forward and reverse limit input, a home input, a high-speed capture trigger input, a position breakpoint output, and an inhibit output. These signals can be used for general-purpose digital I/O when not being used for their motion-specific purpose.

Note Once mapped to an axis, all features and functions of a resource are available as part of the axis. It is not necessary to remember or use the resource number directly when accessing these features, because resources are referenced by axis number once assigned to that axis.

Onboard Programs and Buffers

The 7350 controller has full onboard programmability capable of executing up to 10 simultaneous motion programs.

You can execute the NI-Motion function set from onboard programs. In addition, the onboard programs support basic math and data operation functions for up to 120 general-purpose variables.

The 7350 also features buffered operations for contouring, high-speed position captures, and breakpoints.

You can store and run onboard programs and buffers from RAM or save them to flash ROM. The 7350 controller has 64 KB of RAM and 128 KB of ROM that is divided into two 64 KB sectors for program and buffer storage. You can store and run programs and buffers from either RAM or ROM, but you cannot split programs between the two, and you cannot split programs or buffers between the two 64 KB ROM sectors.

Note Refer to the *NI-Motion User Manual* for detailed information on all of these onboard programming and buffer features.

Host Communications

The host computer communicates with the controller through a number of memory port addresses on the PXI bus.

The primary bidirectional data transfer port supports FIFO data passing in both send and readback directions. The 7350 controller has both a command buffer for incoming commands and a return data buffer (RDB) for returning data.

The communications status register (CSR) provides bits for communications handshaking as well as real-time error reporting and general status feedback to the host PC. The move complete status (MCS) register provides instantaneous motion status of all axes.

The host computer also has a read-only register for reading position and velocity. This feature allows you to read the position and velocity without burdening the onboard CPU.

5

Signal Connections

This chapter describes how to make input and output signal connections directly to the 7350 controller and briefly describes the associated I/O circuitry.

The 7350 controller has the following four connectors that handle all signals to and from the external motion system.

- Two 68-pin motion I/O connectors
- Two 68-pin digital I/O connectors

You can connect to the motion system with cables and accessories, varying from simple screw terminal blocks to enhanced UMI units and drives.

Caution Power off all devices when connecting or disconnecting the 7350 controller motion I/O and auxiliary digital I/O cables. Failure to do so may damage the controller.

Motion I/O Connectors

The motion I/O connectors contain all the signals required to control up to eight axes of servo and stepper motion, including the following features:

- Motor command analog and stepper outputs
- Encoder feedback inputs
- Forward, home, and reverse limit inputs
- Breakpoint outputs
- Trigger inputs
- Inhibit outputs
- Controller shutdown input

The motion I/O connectors also contain up to eight channels of 16-bit A/D inputs for analog feedback or general-purpose analog input.

Figures 5-1 and 5-2 show the pin assignments for the two 68-pin motion I/O connectors on the 7350 controller. A signal description follows the connector pinout. In this chapter, lines above signal names indicate that the signal is active-low.

Axis 1 Dir (CCW)	1	35	Axis 1 Step (CW)
Digital Ground	2	36	Axis 1 Encoder Phase A
Digital Ground	3	37	Axis 1 Encoder Phase B
Axis 1 Home Switch	4	38	Axis 1 Encoder $\overline{\text{Index}}$
Trigger 1	5	39	Axis 1 Forward Limit Switch
Axis 1 $\overline{\text{Inhibit}}$	6	40	Axis 1 Reverse Limit Switch
Axis 2 Dir (CCW)	7	41	Axis 2 Step (CW)
Digital Ground	8	42	Axis 2 Encoder Phase A
Digital Ground	9	43	Axis 2 Encoder Phase B
Axis 2 Home Switch	10	44	Axis 2 Encoder $\overline{\text{Index}}$
Trigger 2	11	45	Axis 2 Forward Limit Switch
Axis 2 $\overline{\text{Inhibit}}$	12	46	Axis 2 Reverse Limit Switch
Axis 3 Dir (CCW)	13	47	Axis 3 Step (CW)
Digital Ground	14	48	Axis 3 Encoder Phase A
Digital Ground	15	49	Axis 3 Encoder Phase B
Axis 3 Home Switch	16	50	Axis 3 Encoder $\overline{\text{Index}}$
Trigger 3	17	51	Axis 3 Forward Limit Switch
Axis 3 $\overline{\text{Inhibit}}$	18	52	Axis 3 Reverse Limit Switch
Axis 4 Dir (CCW)	19	53	Axis 4 Step (CW)
Digital Ground	20	54	Axis 4 Encoder Phase A
Digital Ground	21	55	Axis 4 Encoder Phase B
Axis 4 Home Switch	22	56	Axis 4 Encoder $\overline{\text{Index}}$
Trigger 4	23	57	Axis 4 Forward Limit Switch
Axis 4 $\overline{\text{Inhibit}}$	24	58	Axis 4 Reverse Limit Switch
Digital Ground	25	59	Host +5 V
Breakpoint 1	26	60	Breakpoint 2
Breakpoint 3	27	61	Breakpoint 4
Digital Ground	28	62	Shutdown
Analog Output 1	29	63	Analog Output 2
Analog Output 3	30	64	Analog Output 4
Analog Output Ground	31	65	Reserved
Analog Input 1	32	66	Analog Input 2
Analog Input 3	33	67	Analog Input 4
Analog Reference (Output)	34	68	Analog Input Ground

Figure 5-1. 68-Pin Motion I/O Connector Pin Assignment For Axes 1–4

Axis 5 Dir (CCW)	1	35	Axis 5 Step (CW)
Digital Ground	2	36	Axis 5 Encoder Phase A
Digital Ground	3	37	Axis 5 Encoder Phase B
Axis 5 Home Switch	4	38	Axis 5 Encoder $\overline{\text{Index}}$
Trigger 5	5	39	Axis 5 Forward Limit Switch
Axis 5 $\overline{\text{Inhibit}}$	6	40	Axis 5 Reverse Limit Switch
Axis 6 Dir (CCW)	7	41	Axis 6 Step (CW)
Digital Ground	8	42	Axis 6 Encoder Phase A
Digital Ground	9	43	Axis 6 Encoder $\overline{\text{Phase}}$ B
Axis 6 Home Switch	10	44	Axis 6 Encoder $\overline{\text{Index}}$
Trigger 6	11	45	Axis 6 Forward Limit Switch
Axis 6 $\overline{\text{Inhibit}}$	12	46	Axis 6 Reverse Limit Switch
Axis 7 Dir (CCW)	13	47	Axis 7 Step (CW)
Digital Ground	14	48	Axis 7 Encoder Phase A
Digital Ground	15	49	Axis 7 Encoder Phase B
Axis 7 Home Switch	16	50	Axis 7 Encoder $\overline{\text{Index}}$
Trigger 7	17	51	Axis 7 Forward Limit Switch
Axis 7 $\overline{\text{Inhibit}}$	18	52	Axis 7 Reverse Limit Switch
Axis 8 Dir (CCW)	19	53	Axis 8 Step (CW)
Digital Ground	20	54	Axis 8 Encoder Phase A
Digital Ground	21	55	Axis 8 Encoder Phase B
Axis 8 Home Switch	22	56	Axis 8 Encoder $\overline{\text{Index}}$
Trigger 8	23	57	Axis 8 Forward Limit Switch
Axis 8 $\overline{\text{Inhibit}}$	24	58	Axis 8 Reverse Limit Switch
Digital Ground	25	59	Host +5 V
Breakpoint 5	26	60	Breakpoint 6
Breakpoint 7	27	61	Breakpoint 8
Digital Ground	28	62	Shutdown
Analog Output 5	29	63	Analog Output 6
Analog Output 7	30	64	Analog Output 8
Analog Output Ground	31	65	Reserved
Analog Input 5	32	66	Analog Input 6
Analog Input 7	33	67	Analog Input 8
Analog Reference (Output)	34	68	Analog Input Ground

Figure 5-2. 68-Pin Motion I/O Connector Pin Assignment For Axes 5–8

Table 5-1 describes the signals on the motion I/O connector.

Table 5-1. Motion I/O Signal Connections

Signal Name	Reference	Direction	Description
Digital Ground	—	—	Reference for digital I/O
Axis <1..8> Dir (CCW)	Digital Ground	Output	Motor direction or counter-clockwise control
Axis <1..8> Step (CW)	Digital Ground	Output	Motor step or clockwise control
Axis <1..8> Encoder Phase A	Digital Ground	Input	Closed-loop only—phase A encoder input
Axis <1..8> Encoder Phase B	Digital Ground	Input	Closed-loop only—phase B encoder input
Axis <1..8> Encoder $\overline{\text{Index}}$	Digital Ground	Input	Closed-loop only—index encoder input
Axis <1..8> Home Switch	Digital Ground	Input	Home switch
Axis <1..8> Forward Limit Switch	Digital Ground	Input	Forward limit switch
Axis <1..8> Reverse Limit Switch	Digital Ground	Input	Reverse limit switch
Axis <1..8> $\overline{\text{Inhibit}}$	Digital Ground	Output	Drive inhibit
Trigger <1..8>	Digital Ground	Input	High-speed position capture trigger input <1..8>
Breakpoint <1..8>	Digital Ground	Output	Position breakpoint output <1..8>
Host +5 V	Digital Ground	Output	+5 V—host computer +5 V supply
Analog Input Ground	—	—	Reference for analog inputs
Analog Input <1..8>	Analog Input Ground	Input	16-bit analog input
Analog Output <1..8>	Analog Output Ground	Output	16-bit analog output
Analog Output Ground	—	—	Reference for analog outputs
Shutdown	Digital Ground	Input	Controlled device shutdown
Analog Reference (output)	Analog Output Ground	Output	+7.5 V—analog reference level

Motion Axis Signals

The following signals control the servo amplifier or stepper drive.

- Analog Output <1..8>—These 16-bit DAC outputs are typically the servo command outputs for each axis. They can drive the industry-standard ±10 V output, and can be software limited to

any positive or negative voltage range desired. These outputs also feature a software-programmable voltage offset.

Although typically used as the command output of an axis control loop, unused DACs also can function as independent analog outputs for general-purpose control.

- Analog Reference—For convenience, 7.5 V (nominal) analog reference voltage is available. You can use this output as a low-current supply to sensors that require a stable reference.

Note The analog reference output is an output signal only and must not connect to an external reference voltage. Connect the common of the external reference to the Analog Input Ground pin for proper A/D reference and improved voltage measurement.

- Analog Output Ground—To help keep digital noise separate from the analog DAC outputs, there is a separate return connection. Use this analog ground connection as the reference for the DAC outputs when connecting to servo amplifiers instead of the Digital Ground (digital I/O reference).
- Axis <1..8> Step (CW) and Dir (CCW)—These signals are the stepper command outputs for each axis. The 7350 controller supports both industry standards for stepper command signals: step and direction, or independent clockwise (CW) and counter-clockwise (CCW) pulse outputs.

  The output configuration and signal polarity is software programmable for compatibility with various third-party drives, as follows:

  – When step and direction mode is configured, each commanded step (or microstep) produces a pulse on the step output. The direction output signal level indicates the command direction of motion, either forward or reverse.

  – CW and CCW mode produces pulses (steps) on the CW output for forward-commanded motion and pulses on the CCW output for reverse-commanded motion.

  In either case, you can set the active polarity of both outputs to active-low (inverting) or active-high (non-inverting). For example, with step and direction, you can make a logic high correspond to either forward or reverse direction.

  You can choose to drive the Step (CW) and Dir (CCW) outputs by using either “totem-pole” mode or open-collector mode. In totem-pole mode, the output buffer can both sink and source current, which is appropriate for most applications. In open collector mode, the output

buffer can only sink current. By default, Step (CW) and Dir (CCW) outputs are set to totem-pole mode.

Caution Do *not* connect these outputs to anything other than a +5 V circuit. The output buffers will fail if subjected to voltages in excess of +5.5 V.

- Axis <1..8> Inhibit—Use the inhibit output signals to control the enable/inhibit function of a servo amplifier or stepper drive. When properly connected and configured, the inhibit function causes the connected motor to be de-energized and its shaft turns freely.

  You can set the inhibits to either totem-pole or open-collector mode. In totem-pole mode, the inhibits can both sink and source current. In open collector mode, the output buffer can only sink current. By default, inhibits are set to open-collector mode.

  While the industry standard for inhibits is active-low (inverting), these outputs have programmable polarity and can be set to active-high (non-inverting) for increased flexibility.

  Inhibit output signals can be activated automatically upon a Kill Motion command or any motion error that causes a kill motion condition; a following-error trip, for example.

  You also can use the inhibit outputs of unused axes as general-purpose outputs. However, for safety considerations, National Instruments recommends that you use the inhibit outputs for all active axes.

Limit and Home Inputs

The following signals control limit and home inputs.

- Axis <1..8> Forward Limit Input
- Axis <1..8> Home Input
- Axis <1..8> Reverse Limit Input

These inputs are typically connected to limit switches located at physical ends of travel and/or at a specific home position. Limit and home inputs can be software enabled or disabled at any time. When enabled, an active transition on a limit or home input causes a full torque halt stop of the associated axis. In addition, an active forward or reverse limit input impedes future commanded motion in that direction for as long as the signal is active.

Note Limit and home inputs are digitally filtered and must remain active for a certain amount of time to be recognized. Refer to Appendix A, *Specifications*, for more information. Active signals should remain active to prevent motion from proceeding further into the limit. Pulsed limit signals stop motion, but they do not prevent further motion in that direction if another move is started.

The input polarity of these signals is software programmable for active-low (inverting) or active-high (non-inverting).

You can use software disabled limit and home inputs as general-purpose inputs. You can read the status of these inputs at any time and set and change their polarity as required.

Limit and home inputs are a per axis enhancement on the 7350 controller and are not required for basic motion control. These inputs are part of a system solution for complete motion control.

Caution National Instruments recommends using limits for personal safety, as well as to protect the motion system.

Wiring Concerns

For the end of travel limits to function correctly, the forward limit must be located at the forward or positive end of travel, and the reverse limit at the negative end of travel.

Caution Failure to follow these guidelines may result in motion that stops at, but then travels through, a limit, potentially damaging the motion system. Limits that are wired incorrectly may prevent motion from occurring at all.

Keep limit and home switch signals and their ground connections wired separately from the motor drive/amplifier signal and encoder signal connections.

Caution Wiring these signals near each other can cause faulty motion system operation that is caused by signal noise and crosstalk.

Limit and Home Input Circuit

All limit and home inputs are digitally filtered and must be active for a certain amount of time to be recognized. Refer to Appendix A, *Specifications*, for more information. These inputs have an onboard pull-up resistor. If left floating, the inputs are interpreted as a high logic level.

Caution Excessive input voltages can cause erroneous operation and/or component failure. Verify that the input voltage is within the specification range.

Encoder Signals

The 7350 controller offers up to eight channels of single-ended quadrature encoder inputs. All National Instruments power drives and UMI accessories provide built-in circuitry that converts differential encoder signals to single-ended encoder signals. Each channel consists of a Phase A, Phase B, and Index input, as described in the following sections.

Encoder <1..8> Phase A/Phase B

The encoder inputs provide position and velocity feedback for absolute and relative positioning of axes in any motion system configuration.

If an encoder resource is not needed for axis control, it is available for other functions including position monitoring, digital potentiometer encoder inputs, or as a master encoder input for master/slave (electronic gearing) applications.

The encoder channels (Encoder <1..8>) are implemented in an FPGA and are high performance with advanced features, such as high-speed position capture inputs and position breakpoint outputs.

An encoder input channel converts quadrature signals on Phase A and Phase B into 32-bit up/down counter values. Quadrature signals are generated by optical, magnetic, laser, or electronic devices that provide two signals, Phase A and Phase B, that are 90° out of phase. The leading phase, A or B, determines the direction of motion. The four transition states of the relative signal phases provide distinct pulse edges that cause count up or count down pulses in the direction determined by the leading phase.

A typical encoder with a specification of N (N = number) lines per unit of measure (revolutions or linear distance) produces $4 \times N$ quadrature counts per unit of measure. The count is the basic increment of position in National Instruments motion systems.

Note Determine quadrature counts by multiplying the encoder resolution, in encoder lines, by 4. The encoder resolution is the number of encoder lines between consecutive encoder indexes , such as marker or Z-bit. If the encoder does not have an index output, the resolution is referred to as lines per revolution, or lines per unit of measure: inch, centimeter, millimeter, and so on.

Encoder <1..8> Index

The Index input is primarily used to establish a reference position. This function uses the number of counts per revolution or the linear distance to initiate a search move that locates the index position. When a valid Index signal transition occurs during a Find Reference routine, the position of the Index signal is captured accurately. Use this captured position to establish a reference zero position for absolute position control or any other motion system position reference required.

The default MAX settings guarantee that the Find Index routine completes successfully if the encoder generates a high index pulse when phases A and B are low and the encoder is connected through an NI UMI or drive accessory. Figure 5-3 shows the default encoder phasing diagram at the inputs to an NI UMI or drive accessory.

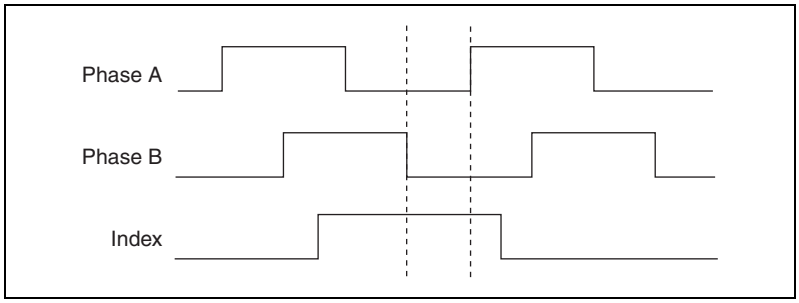


Figure 5-3. Quadrature Encoder Phasing Diagram

You can set the index reference criteria in MAX to change the pattern of phases A and B for the index search. You also can set the encoder polarity for phases A, B, and I in MAX.

Wiring Concerns

The encoder inputs are connected to quadrature decoder/counter circuits. It is very important to minimize noise at this interface. Excessive noise on these encoder input signals may result in loss of counts or extra counts and erroneous closed-loop motion operation. Verify the encoder connections before powering up the system.

Caution Wire encoder signals and their ground connections separately from all other connections. Wiring these signals near the motor drive/amplifier or other signals can cause positioning errors and faulty operation.

Encoders with differential line drive outputs are strongly recommended for all applications and must be used if the encoder cable length is longer than 10 ft (3.05 m). Shielded, 24 AWG wire is the minimum recommended size for the encoder cable. Cables with twisted pairs and an overall shield are recommended for optimized noise immunity.

All National Instruments power drives and UMI accessories provide built-in circuitry that converts differential encoder signals to single-ended encoder signals.

Caution Unshielded cables can cause noise to corrupt the encoder signals, resulting in lost or additional counts and reduced motion system accuracy.

Encoder Input Circuit

The Phase A, Phase B, and Index encoder inputs all have an onboard pull-up resistor, and are interpreted as high logic level if left floating. Both phases A and B are required for proper encoder counter operation, and the signals must support the 90° phase difference within system tolerance. The encoder and Index signals are conditioned by a software-programmable digital filter inside the FPGA. The Index signal is optional but highly recommended and is required for initialization functionality with the Find Reference function.

Trigger Inputs, Shutdown Input, and Breakpoint Outputs

The 7350 controller offers additional high-performance features. The encoder channels have high-speed position capture trigger inputs and position breakpoint outputs. These signals are useful for high-speed synchronization of motion with actuators, sensors, and other parts of the complete motion system:

- Trigger Input <1..8>—When enabled, an active transition on a high-speed position capture input causes instantaneous position capture of the corresponding encoder count value. You can use this high-speed position capture functionality for applications ranging from simple position tagging of sensor data to complex camming systems with advance/retard positioning and registration. An available 7350 controller position mode is to move an axis Relative to Captured Position.

  The polarity of the trigger input is programmable in software as active-low (inverting), or active-high (non-inverting), rising edge or falling edge. You can also use a trigger input as a latching general-purpose digital input by simply ignoring the captured position.

- Shutdown Input—When enabled in software, the shutdown input signal can be used to kill all motion by asserting the controller inhibits, setting the analog outputs to 0 V, and stopping any stepper pulse generation. To activate shutdown, the signal must transition from a low to high state.
- Breakpoint Output <1..8>—You can program a breakpoint output to transition when the associated encoder value equals the breakpoint position. You can use a breakpoint output to directly control actuators or as a trigger to synchronize data acquisition or other functions in the motion control system.

  You can program breakpoints as either *absolute*, *relative*, *periodic*, or *buffered* positions. Breakpoint outputs can be preset to a known state so that the transition when the breakpoint occurs can be low to high, high to low, toggle, or pulse.

  You can set the breakpoint outputs to be totem-pole mode or open-collector mode. In totem-pole mode, the output buffer can both sink and source current, which is appropriate for most applications. In open-collector mode, the output buffer can only sink current. By default, breakpoint outputs are set to totem-pole mode.

  You can directly set and reset breakpoint outputs to use them as general-purpose digital outputs.

Wiring Concerns

Caution Keep trigger input, shutdown input, and breakpoint output signals and their ground connections wired separately from the motor drive/amplifier signal and encoder signal connections. Wiring these signals near each other can cause faulty operation.

Caution Excessive input voltages can cause erroneous operation and/or component failure.

Trigger Input and Shutdown Input Circuits

Trigger input and shutdown input circuits feature onboard pull-up resistors that interpret the inputs as high logic level if left floating.

Analog Inputs

The 7350 controller has the following ADC input signals:

- Analog Input <1..8>—The 7350 controller includes an eight-channel multiplexed, 16-bit ADC capable of measuring ±10 V, ±5 V, 0–10 V, and 0–5 V inputs.

You can configure each ADC channel for motion feedback, simple A/D conversion, or both.

You can read the digital value of analog voltage on any of the ADC channels of the controller by using the Read ADC function. Table 5-2 shows the range of values read back and the voltage resolution for each setting. The voltage resolution is in microvolts per least significant bit (µV/LSB).

Table 5-2. Analog Input Voltage Ranges

Input Range	Binary Values	Resolution
±10 V	–32,768 to 32,767	305 µV/LSB
±5 V	–32,768 to 32,767	153 µV/LSB
0–10 V	0 to 65,535	153 µV/LSB
0–5 V	0 to 65,535	76 µV/LSB

When configured as analog feedback, an analog sensor acts like a limited range absolute position device with a full-scale position range. You can map any ADC channel as feedback to any axis.

You can enable and disable individual ADC channels in software. Disable unused ADC channels for the highest multiplexer scan rate performance. Properly enabled, the scan rate is high enough to support analog feedback at the highest PID sample rate.

- Analog Input Ground—To help keep digital noise out of the analog input, a separate return connection is available. Use this reference ground connection and not Digital Ground (digital I/O reference) or Analog Output Ground as the reference for the analog inputs.

Wiring Concerns

For proper use of each ADC input channel, the analog signal to be measured should be connected to the channel input and its ground reference connected to the Analog Input Ground.

Other Motion I/O Connection

The 7350 controller provides the following other motion I/O connection:

- Host +5 V—This signal is the internal +5 V supply of the host computer. It is typically used to detect when the host computer is powered and to shut down external motion system components when the host computer is powered off or disconnected from the motion accessory.

Caution The host +5 V signal is limited and should not be used to power any external devices, except those intended in the host bus monitor circuits on the UMI and drive products.

Interfacing With Optocouplers

Many motor drive manufacturers offer opto-isolated inputs for Step (CW)/Dir (CCW) and other motion control signals. The 7350 is well-suited to drive most of these inputs directly when you connect the controller output signal to the positive side of the optocoupler input and connect the controller GND to the negative side of the optocoupler input. This method works if the optocoupler is designed to work with a 5 V signal, requires less current than the maximum the controller can supply, and the 7350 output is configured for totem-pole output mode. Figure 5-4 shows a typical optocoupler wiring example.

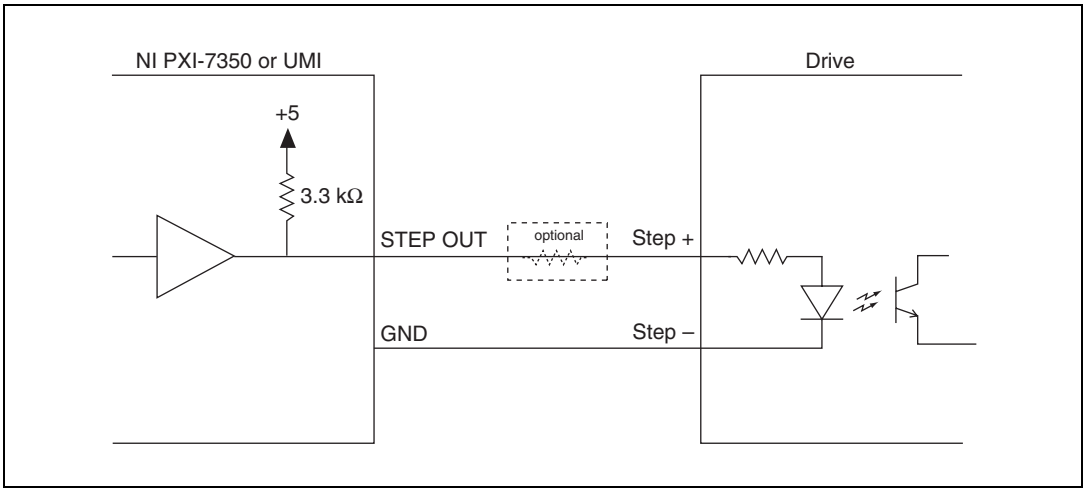


Figure 5-4. Typical Optocoupler Wiring (Totem-Pole Output Mode)

In some rare circumstances, the optocoupler will not work with a 5 V signal, or it requires more current than the maximum the controller can provide. In this case, connect the controller output to the negative side of the optocoupler input, connect the positive side of the input to a supply as specified by the drive manufacturer, and configure the controller output for open collector mode. Figure 5-5 shows this special case wiring example.

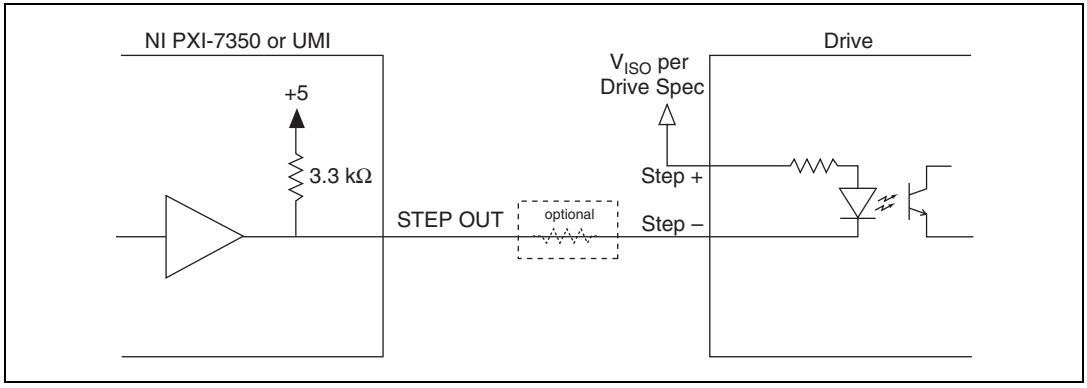


Figure 5-5. Special Case Optocoupler Wiring (Open-Collector Output Mode)

Caution If the optocoupler input does not include its own current-limiting resistor, you must provide an external resistor in series with the 7350 output. To prevent damage to the 7350 or other motion hardware, use a resistor that limits the current to a value below the maximum specifications of the controller and other hardware.

Digital I/O Connector

The general-purpose digital I/O lines on the 7350 controller are available on two separate 68-pin digital I/O connectors. Figures 5-6 and 5-7 show the pin assignments for these connectors.

+5 V	1	35	Digital Ground
PCLK	2	36	Digital Ground
Reserved	3	37	Digital Ground
Reserved	4	38	DPull (P1:P4)
PWM1	5	39	Digital Ground
Reserved	6	40	Reserved
Reserved	7	41	Digital Ground
Reserved	8	42	Digital Ground
PWM2	9	43	Digital Ground
Port 1:bit 0	10	44	Port 1:bit 1
Digital Ground	11	45	Port 1:bit 2
Port 1:bit 3	12	46	Digital Ground
Port 1:bit 4	13	47	Port 1:bit 5
Digital Ground	14	48	Port 1:bit 6
Port 1:bit 7	15	49	Digital Ground
Port 2:bit 0	16	50	Digital Ground
Port 2:bit 1	17	51	Port 2:bit 2
Digital Ground	18	52	Port 2:bit 3
Digital Ground	19	53	Port 2:bit 4
Digital Ground	20	54	Port 2:bit 5
Port 2:bit 6	21	55	Digital Ground
Port 2:bit 7	22	56	Digital Ground
Port 3:bit 0	23	57	Port 3:bit 1
Digital Ground	24	58	Port 3:bit 2
Port 3:bit 3	25	59	Digital Ground
Port 3:bit 4	26	60	Port 3:bit 5
Digital Ground	27	61	Port 3:bit 6
Port 3:bit 7	28	62	Digital Ground
Port 4:bit 0	29	63	Port 4:bit 1
Digital Ground	30	64	Port 4:bit 2/Axis 1, Hall 1
Axis 1, Hall 2/Port 4:bit 3	31	65	Digital Ground
Axis 1, Hall 3/Port 4:bit 4	32	66	Port 4:bit 5/Axis 2, Hall 1
Digital Ground	33	67	Port 4:bit 6/Axis 2, Hall 2
Axis 2, Hall 3/Port 4:bit 7	34	68	Digital Ground

Figure 5-6. 68-Pin Digital I/O Connector Pin Assignments (Ports 1–4)

+5 V	1	35	Digital Ground
Reserved	2	36	Digital Ground
Reserved	3	37	Digital Ground
Reserved	4	38	DPull (P5:P8)
Reserved	5	39	Digital Ground
Reserved	6	40	Reserved
Reserved	7	41	Digital Ground
Reserved	8	42	Digital Ground
Reserved	9	43	Digital Ground
Port 5:bit 0	10	44	Port 5:bit 1
Digital Ground	11	45	Port 5:bit 2
Port 5:bit 3	12	46	Digital Ground
Port 5:bit 4	13	47	Port 5:bit 5
Digital Ground	14	48	Port 5:bit 6
Port 5:bit 7	15	49	Digital Ground
Port 6:bit 0	16	50	Digital Ground
Port 6:bit 1	17	51	Port 6:bit 2
Digital Ground	18	52	Port 6:bit 3
Digital Ground	19	53	Port 6:bit 4
Digital Ground	20	54	Port 6:bit 5
Port 6:bit 6	21	55	Digital Ground
Port 6:bit 7	22	56	Digital Ground
Port 7:bit 0	23	57	Port 7:bit 1
Digital Ground	24	58	Port 7:bit 2
Port 7:bit 3	25	59	Digital Ground
Port 7:bit 4	26	60	Port 7:bit 5
Digital Ground	27	61	Port 7:bit 6
Port 7:bit 7	28	62	Digital Ground
Port 8:bit 0	29	63	Port 8:bit 1
Digital Ground	30	64	Port 8:bit 2/Axis 3, Hall 1
Axis 3, Hall 2/Port 8:bit 3	31	65	Digital Ground
Axis 3, Hall 3/Port 8:bit 4	32	66	Port 8:bit 5/Axis 4, Hall 1
Digital Ground	33	67	Port 8:bit 6/Axis 4, Hall 2
Axis 4, Hall 3/Port 8:bit 7	34	68	Digital Ground

Figure 5-7. 68-Pin Digital I/O Connector Pin Assignments (Ports 5–8)

The 64-bit digital I/O ports are configured in hardware as up to eight 8-bit digital I/O ports. The bits in a port are typically controlled and read with byte-wide bitmapped commands.

Bits 2–7 in DIO ports 4 and 8 are dual-purpose bits that can be used for either general-purpose I/O or Hall sensor feedback during system configuration and initialization, but not both. Once you set these bits to provide Hall sensor feedback, they are reserved for this activity and cannot be used for general-purpose I/O until you reinitialize your motion system.

All digital I/O lines have programmable direction and polarity.

The DPull(P1:P4) and DPull(P5:P8) pins control the state of the digital input pins at power-up.

Connecting DPull(P1:P4) to +5 V or leaving it unconnected configures all pins in Ports 1–4 for 10 kΩ pull-ups. Connecting DPull(P1:P4) to ground configures these ports for 10 kΩ pull-downs.

Connecting DPull(P5:P8) to +5 V or leaving it unconnected configures all pins in Ports 5–8 for 10 kΩ pull-ups. Connecting DPull(P5:P8) to ground configures these ports for 10 kΩ pull-downs.

PWM Features

The 7350 controller provides two pulse width modulation (PWM) outputs on the digital I/O connector for ports 1–4. The PWM outputs generate periodic waveforms whose period and duty cycles can be independently controlled through software commands. You can compare PWM to a digital representation of an analog value, because the duty cycle is directly proportional to the desired output value. PWM outputs are typically used for transmitting an analog value through an optocoupler. A simple lowpass filter turns a PWM signal back into its corresponding analog value.
If appropriate, you can use an external clock source connected to the PCLK input instead of the internal source as the clock for the PWM generators.

Note These signals are configured in software and are in no way associated with the PID servo control loop. Refer to the appropriate NI-Motion documentation for more information.

RTSI Connector

The PXI-7350 uses the PXI chassis backplane to connect to other RTSI-capable devices. No external cables or connectors are necessary to use the RTSI bus.

RTSI Signal Considerations

The 7350 motion controller allows you to use up to eight RTSI trigger lines as sources for trigger inputs, or as destinations for breakpoint outputs and encoder signals. The RTSI trigger lines can also serve as a generic digital I/O port. The RTSI star trigger line can only be used for a trigger input. Breakpoint outputs are output-only signals that generate an active-high pulse of 200 ns duration, as shown in Figure 5-8.

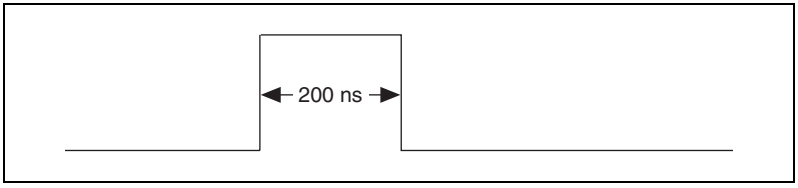


Figure 5-8. Breakpoint across RTSI

Encoder and Index signals are output-only signals across RTSI that are the digitally-filtered versions of the raw signals coming into the controller. If you are using the RTSI bus for trigger inputs or generic digital I/O, all signals are passed through unaltered.

A

Specifications

This appendix lists the hardware and software performance specifications for the 7350 controller. Hardware specifications are typical at 25 °C, unless otherwise stated.

Servo Performance

PID update rate range ..... 62.5 to 500 µs/sample
- Max PID update rate ..... 62.5 µs per 2 axes
- 8-axis PID update rate ..... 250 µs total

Trajectory update rate ..... Same as PID update rate

Multi-axis synchronization ..... <1 update sample

Position accuracy
- Encoder feedback ..... ±1 quadrature count
- Analog feedback ..... ±1 LSB

Double-buffered trajectory parameters
- Absolute position range ..... $\pm 2^{31}$ counts
- Max relative move size ..... $\pm 2^{31}$ counts
- Velocity range ..... 1 to ±20,000,000 counts/s
- RPM range[1] ..... ±1,200,000 revolutions/minute
- Acceleration/deceleration[1] ..... ±512,000,000 counts/s^2
- RPS/s range[1] ..... ±256,000 revolutions/s^2
- S-Curve time range ..... 1 to 32,767 samples
- Following error range ..... 0 to 32,767 counts
- Gear ratio ..... ±32,767:1 to ±1:32,767

Servo control loop modes ..... PID, PIVff, S-Curve, Dual Loop
- PID (Kp, Ki and Kd) gains ..... 0 to 32,767
- Integration limit (Ilim) ..... 0 to 32,767

[1] Assumes a PID update rate of 250 µs and a 2,000-count encoder.

Derivative sample period (Td).....1 to 63 samples
Feedforward (Aff, Vff) gains .....0 to 32,767
Velocity feedback (Kv) gain .....0 to 32,767

Servo command analog outputs
Voltage range.....±10 V
Resolution.....16 bits (0.000305 V/LSB)
Programmable torque (velocity) limits
Positive limit .....±10 V (–32,768 to +32,767)
Negative limit.....±10 V (–32,768 to +32,767)
Programmable offset .....±10 V (–32,768 to +32,767)

Stepper Performance

Trajectory update rate range .....62.5 to 500 µs/sample
Max update rate .....62.5 µs per 2 axes
8-axis update rate.....250 µs total

Multi-axis synchronization .....<1 update sample

Position accuracy
Open-loop stepper .....1 full, half, or microstep
Encoder feedback .....±1 quadrature count
Analog feedback.....±1 LSB

Double-buffered trajectory parameters
Position range .....$\pm 2^{31}$ steps
Max relative move size.....$\pm 2^{31}$ steps
Velocity range .....1 to 8,000,000 steps/s
RPM range[1] .....±1,200,000 revolutions/minute
Acceleration/deceleration[1].....±512,000,000 steps/s^2
RPS/s range[1] .....±256,000 revolutions/s^2
S-curve time range.....1 to 32,767 samples
Following error range .....0 to 32,767 counts
Gear ratio.....±32,767:1 to ±1:32,767

[1] Assumes a PID update rate of 250 µs and a 2,000-count encoder.

Stepper outputs

- Max pulse rate ..... 8 MHz (full, half, and microstep)
- Max pulse width ..... 6.5 µs at <40 kHz
- Min pulse width ..... 40 ns at >4 MHz
- Step output mode ..... Step and direction or CW/CCW
- Voltage range ..... 0 to 5 V
  - Output low voltage ..... 0.6 V at 64 mA sink
  - Output high voltage ..... Totem pole: 2V at 16 mA source; open collector: built-in 3.3 kΩ pull-up to +5 V
- Polarity ..... Programmable, active-high or active-low

System Safety

Watchdog timer function ..... Resets board to startup state

- Watchdog timeout ..... 63 or 256 ms (programmable)

Shutdown input

- Voltage range ..... 0 to 5 V
  - Input low voltage ..... 0.8 V
  - Input high voltage ..... 2 V
  - Polarity ..... Rising edge
- Control ..... Disable all axes and command outputs; resets I/O to default states

Host +5 V Max current sourced from controller ..... 100 mA at 5 V

Motion I/O

Encoder inputs ..... Quadrature, incremental, single-ended

- Max count rate ..... 20 MHz
- Min pulse width ..... Programmable; depends on digital filter settings
- Voltage range ..... 0 to 5 V
  - Input low voltage ..... 0.8 V
  - Input high voltage ..... 2 V

Min index pulse width.....Programmable; depends on digital filter settings

Forward, reverse, and home inputs

Number of inputs.....3 per axis, up to 24

Voltage range.....0 to 5 V

Input low voltage.....0.8 V

Input high voltage.....2 V

Polarity .....Programmable, active-high or active-low

Min pulse width.....800 µs

Control.....Individual enable/disable, stop on input, prevent motion, Find Reference

Trigger inputs

Number of inputs.....Up to 8 (Encoders 1 through 8)

Voltage range.....0 to 5 V

Input low voltage.....0.8 V

Input high voltage.....2 V

Polarity .....Programmable, active-high or active-low

Min pulse width.....100 ns

Max capture latency .....100 ns

Capture accuracy .....1 count

Max capture rate (non-buffered) .....150 Hz

Max buffered capture rate[1].....2 kHz per axis

Breakpoint outputs

Number of outputs.....Up to 8 (Encoders 1 through 8)

Voltage range.....0 to 5 V

Output low voltage.....0.6 V at 64 mA sink

Output high voltage.....Totem pole: 2 V at 16 mA source; open collector: built-in 3.3 kΩ pull-up to +5 V

[1] Assumes a PID update rate of 250 µs. 2 kHz per axis for PID rates between 62.5 and 250 µs, and 1 kHz per axis for PID rates greater than 250 µs. This value is not to exceed 8 kHz total for all ongoing buffered breakpoint and trigger operation.

Polarity ..... Programmable, active-high or active-low

Max trigger rate (non-buffered) ..... 150 Hz

Max buffered trigger rate[1] ..... 2 kHz per axis

Max periodic rate ..... 4 MHz per axis

Pulse width (pulse mode only) ..... 200 ns

Inhibit/enable output

Number of outputs ..... 1 per axis, up to 8

Voltage range ..... 0 to 5 V

Output low voltage ..... 0.6 V at 64 mA sink

Output high voltage ..... Totem pole: 2 V at 16 mA source; open collector: built-in 3.3 kΩ pull-up to +5 V

Polarity ..... Programmable, active-high or active-low

Control ..... MustOn/MustOff or automatic when axis off

Analog inputs

Control ..... Assigned to axis for analog feedback or general-purpose analog input

Number of inputs ..... Up to 8, multiplexed, single-ended

Multiplexer scan rate ..... 25 µs per enabled ADC

Input coupling ..... DC

Input impedance ..... 100 MΩ min

Voltage range (programmable) ..... ±10 V, ±5 V, 0–10 V, 0–5 V

Bandwidth ..... 234 kHz

Resolution ..... 16 bits, no missing codes

Monotonicity ..... Guaranteed

Absolute accuracy

All ranges ..... 0.5% of full-scale

[1] Assumes a PID update rate of 250 µs. 2 kHz per axis for PID rates between 62.5 and 250 µs, and 1 kHz per axis for PID rates greater than 250 µs. This value is not to exceed 8 kHz total for all ongoing buffered breakpoint and trigger operation.

System noise

- ±10 V ..... 220 µVrms, typical
- ±5 V ..... 120 µVrms, typical
- 0–10 V ..... 130 µVrms, typical
- 0–5 V ..... 60µVrms, typical

Linearity

- All ranges 61ppm
- Maximum working voltage ..... ±11 V
- Overvoltage protection
- Powered on ..... ±25 V
- Powered off ..... ±15 V

Analog outputs

- Number of outputs ..... Up to 8, single-ended
- Output coupling ..... DC
- Voltage range ..... ±10 V
- Output current ..... ±5 mA
- Minimum load ..... 2 kΩ at full-scale
- Resolution ..... 16 bits, no missing codes
- Monotonicity ..... Guaranteed
- Absolute accuracy ..... 0.5% of full-scale
- Noise ..... 100 µVrms Max
- Protection ..... Short-circuit to ground
- Settling Time ..... 15 µs, full-scale step
- Analog reference output ..... 7.5 V (nominal)

Digital I/O

Ports ..... Up to 8, 8-bit ports

- Line direction ..... Individual bit programmable

Inputs

- Voltage range ..... 0 to 5 V
  - Input low voltage ..... 0.8 V
  - Input high voltage ..... 2.0 V
- Polarity ..... Programmable, active-high or active-low

Outputs

- Voltage range ..... 0 to 5 V
  - Output low voltage ..... 0.45 V at 24 mA
  - Output high voltage ..... 2.4 V at 24 mA
- Max total DIO current
  - Sourced from controller ..... 1 A
- Polarity ..... Programmable, active-high or active-low
- PWM outputs
  - Number of PWM outputs 2
  - Max PWM frequency ..... 50 kHz
  - Resolution 8-bit
  - Duty cycle range ..... 0 to (255/256)%
  - Clock sources ..... Internal or external

RTSI

Trigger Lines 8

PXI Star Trigger 1

Maximum Power Requirements

+3.3 V (±10%) ..... 2 A

+5 V (±5%) ..... 2 A

+12 V (±5%) ..... 30 mA

–12 V (±3%) ..... 0 mA

Power consumption ..... 18 W

Physical

Dimensions (Not Including Connectors)

PXI-7350 ..... 16 by 10 cm (6.3 by 3.9 in.)

Connectors

Motion I/O connectors.....2 68-pin female high-density VHDCI type

32-bit digital I/O connectors.....2 68-pin female high-density VHDCI type

Weight

PXI-7350 .....170 g (6 oz)

Maximum Working Voltage

Channel to earth.....11 V, Installation Category 1 (signal voltage plus common-mode voltage)

Channel to channel .....22 V, Installation Category 1 (signal voltage plus common-mode voltage)

Caution These values represent the maximum allowable voltage between any accessible signals on the controller. To determine the acceptable voltage range for a particular signal, please refer to the individual signal specifications.

Environment

Operating temperature ..... 0 to 55 °C

Storage temperature.....–20 to 70 °C

Humidity.....10 to 90% RH, noncondensing

Maximum altitude.....2,000 m

Pollution Degree 2

Electromagnetic Compatibility

Emissions	EN 55011 Class A at 10 m FCC Part 15A above 1 GHz
Immunity	EN 61326-1:1997 + A2:2001, Table 1
CE	C-Tick and FCC Part 15(ClassA) Compliant

Note For EMC compliance, you *must* operate this device with shielded cabling.

CE Compliance

This product meets the essential requirements of applicable European Directives, as amended for CE Marking, as follows:

Low-Voltage Directive (safety)	73/23/EEC
Electromagnetic Compatibility Directive (EMC)	89/336/EEC

Note Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain the DoC for this product, click **Declarations of Conformity Information** at `ni.com/hardref.nsf/`. This Web site lists the DoCs by product family. Select the appropriate product family, followed by your product, and a link to the DoC appears in Adobe Acrobat format. Click the **Acrobat** icon to download or read the DoC.

Safety

This product is designed to meet the requirements of the following standards of safety for electrical equipment for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 3111-1, UL 61010B-1
- CAN/CSA C22.2 No. 1010.1

Note For UL and other safety certifications, refer to the product label or to `ni.com`.

B

Cable Connector Descriptions

This appendix describes the connector pinout for the cables that connect to the 7350 controller.

Figures B-1 and B-2 show the pin assignments for the stepper 50-pin motion connectors, while Figures B-3 and B-4 show the pin assignments for the servo 50-pin motion connectors. These connectors are available when you use the SH68-C68-S shielded cable assembly and the 68M-50F step/servo bulkhead cable adapter.

Axis 1 Dir (CCW)	1	2	Axis 1 Step (CW)
Digital Ground	3	4	Axis 1 Encoder Phase A
Digital Ground	5	6	Axis 1 Encoder Phase B
Axis 1 Home Switch	7	8	Axis 1 Encoder $\overline{\text{Index}}$
Trigger/Breakpoint 1	9	10	Axis 1 Forward Limit Switch
Axis 1 $\overline{\text{Inhibit}}$	11	12	Axis 1 Reverse Limit Switch
Axis 2 Dir (CCW)	13	14	Axis 2 Step (CW)
Digital Ground	15	16	Axis 2 Encoder Phase A
Digital Ground	17	18	Axis 2 Encoder Phase B
Axis 2 Home Switch	19	20	Axis 2 Encoder $\overline{\text{Index}}$
Trigger/Breakpoint 2	21	22	Axis 2 Forward Limit Switch
Axis 2 $\overline{\text{Inhibit}}$	23	24	Axis 2 Reverse Limit Switch
Axis 3 Dir (CCW)	25	26	Axis 3 Step (CW)
Digital Ground	27	28	Axis 3 Encoder Phase A
Digital Ground	29	30	Axis 3 Encoder Phase B
Axis 3 Home Switch	31	32	Axis 3 Encoder $\overline{\text{Index}}$
Trigger/Breakpoint 3	33	34	Axis 3 Forward Limit Switch
Axis 3 $\overline{\text{Inhibit}}$	35	36	Axis 3 Reverse Limit Switch
Axis 4 Dir (CCW)	37	38	Axis 4 Step (CW)
Digital Ground	39	40	Axis 4 Encoder Phase A
Digital Ground	41	42	Axis 4 Encoder Phase B
Axis 4 Home Switch	43	44	Axis 4 Encoder $\overline{\text{Index}}$
Trigger/Breakpoint 4	45	46	Axis 4 Forward Limit Switch
Axis 4 $\overline{\text{Inhibit}}$	47	48	Axis 4 Reverse Limit Switch
Digital Ground	49	50	Host +5 V

Figure B-1. 50-Pin Stepper Connector Pin Assignment (Axes 1–4)

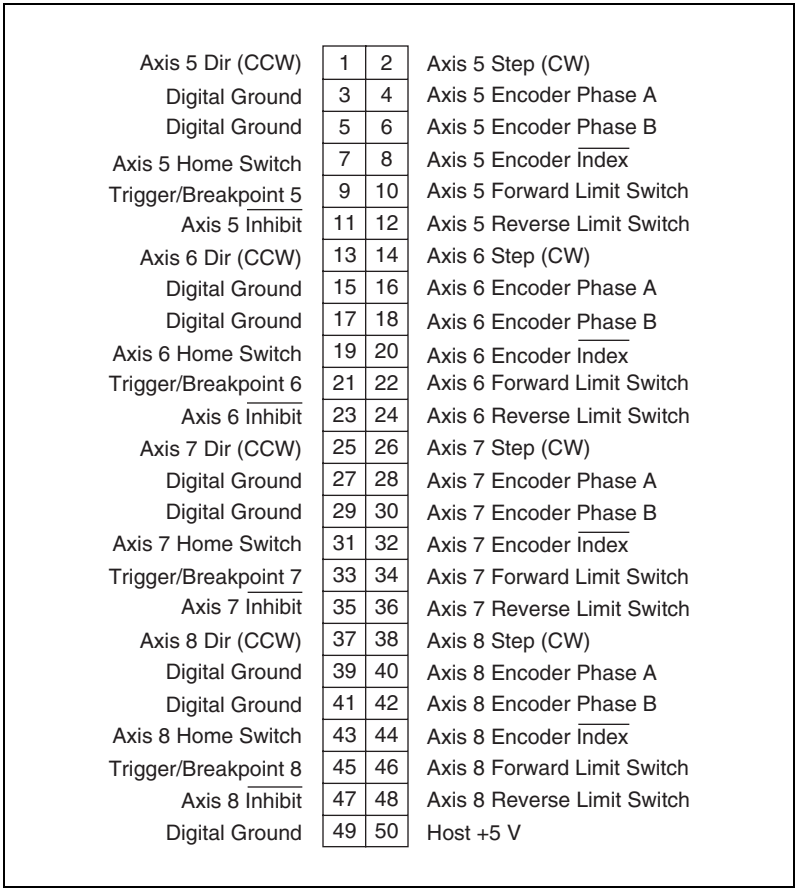

Axis 5 Dir (CCW) 1 2 Axis 5 Step (CW)
Digital Ground 3 4 Axis 5 Encoder Phase A
Digital Ground 5 6 Axis 5 Encoder Phase B
Axis 5 Home Switch 7 8 Axis 5 Encoder Index
Trigger/Breakpoint 5 9 10 Axis 5 Forward Limit Switch
Axis 5 Inhibit 11 12 Axis 5 Reverse Limit Switch
Axis 6 Dir (CCW) 13 14 Axis 6 Step (CW)
Digital Ground 15 16 Axis 6 Encoder Phase A
Digital Ground 17 18 Axis 6 Encoder Phase B
Axis 6 Home Switch 19 20 Axis 6 Encoder Index
Trigger/Breakpoint 6 21 22 Axis 6 Forward Limit Switch
Axis 6 Inhibit 23 24 Axis 6 Reverse Limit Switch
Axis 7 Dir (CCW) 25 26 Axis 7 Step (CW)
Digital Ground 27 28 Axis 7 Encoder Phase A
Digital Ground 29 30 Axis 7 Encoder Phase B
Axis 7 Home Switch 31 32 Axis 7 Encoder Index
Trigger/Breakpoint 7 33 34 Axis 7 Forward Limit Switch
Axis 7 Inhibit 35 36 Axis 7 Reverse Limit Switch
Axis 8 Dir (CCW) 37 38 Axis 8 Step (CW)
Digital Ground 39 40 Axis 8 Encoder Phase A
Digital Ground 41 42 Axis 8 Encoder Phase B
Axis 8 Home Switch 43 44 Axis 8 Encoder Index
Trigger/Breakpoint 8 45 46 Axis 8 Forward Limit Switch
Axis 8 Inhibit 47 48 Axis 8 Reverse Limit Switch
Digital Ground 49 50 Host +5 V

Figure B-2. 50-Pin Stepper Connector Pin Assignment (Axes 5–8)

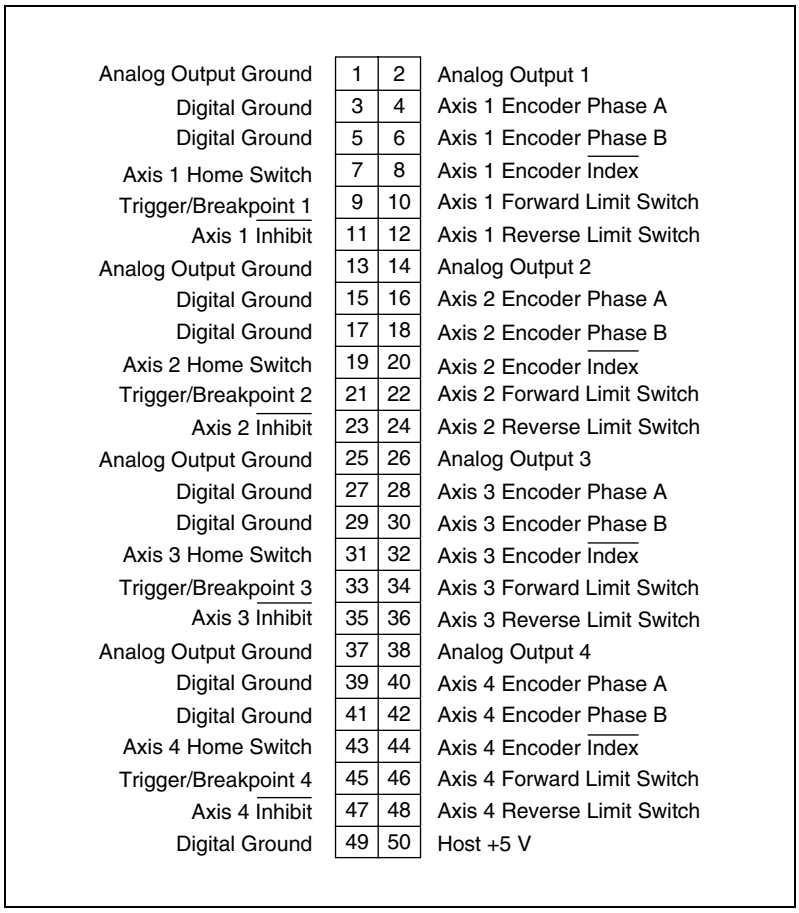

Analog Output Ground 1 2 Analog Output 1
Digital Ground 3 4 Axis 1 Encoder Phase A
Digital Ground 5 6 Axis 1 Encoder Phase B
Axis 1 Home Switch 7 8 Axis 1 Encoder Index
Trigger/Breakpoint 1 9 10 Axis 1 Forward Limit Switch
Axis 1 Inhibit 11 12 Axis 1 Reverse Limit Switch
Analog Output Ground 13 14 Analog Output 2
Digital Ground 15 16 Axis 2 Encoder Phase A
Digital Ground 17 18 Axis 2 Encoder Phase B
Axis 2 Home Switch 19 20 Axis 2 Encoder Index
Trigger/Breakpoint 2 21 22 Axis 2 Forward Limit Switch
Axis 2 Inhibit 23 24 Axis 2 Reverse Limit Switch
Analog Output Ground 25 26 Analog Output 3
Digital Ground 27 28 Axis 3 Encoder Phase A
Digital Ground 29 30 Axis 3 Encoder Phase B
Axis 3 Home Switch 31 32 Axis 3 Encoder Index
Trigger/Breakpoint 3 33 34 Axis 3 Forward Limit Switch
Axis 3 Inhibit 35 36 Axis 3 Reverse Limit Switch
Analog Output Ground 37 38 Analog Output 4
Digital Ground 39 40 Axis 4 Encoder Phase A
Digital Ground 41 42 Axis 4 Encoder Phase B
Axis 4 Home Switch 43 44 Axis 4 Encoder Index
Trigger/Breakpoint 4 45 46 Axis 4 Forward Limit Switch
Axis 4 Inhibit 47 48 Axis 4 Reverse Limit Switch
Digital Ground 49 50 Host +5 V

Figure B-3. 50-Pin Servo Connector Pin Assignment (Axes 1–4)

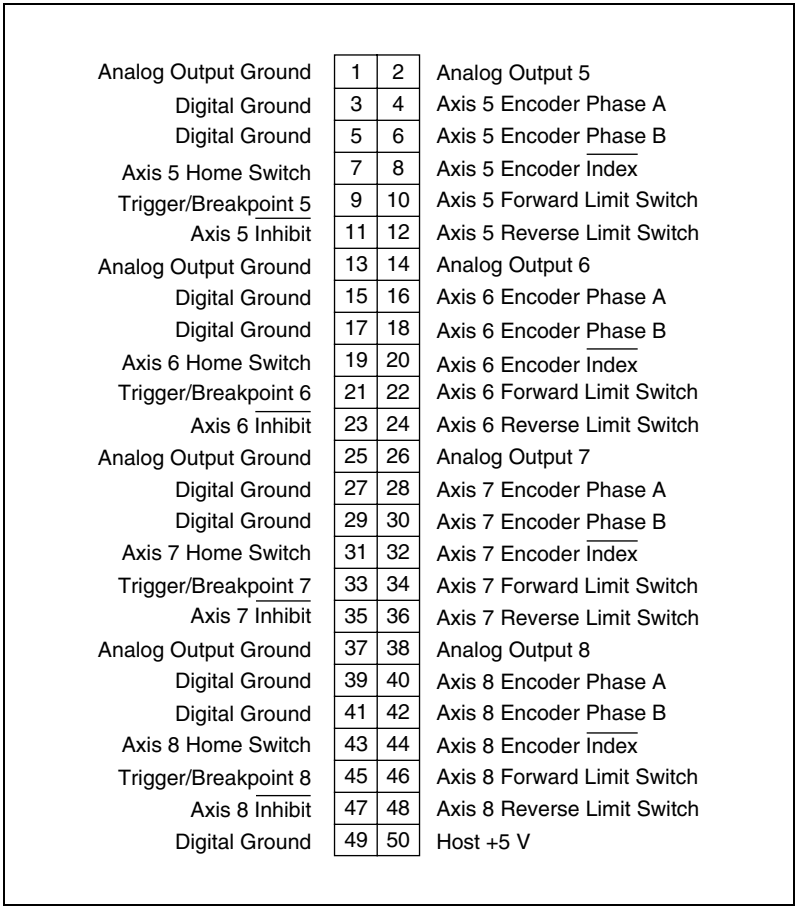

Analog Output Ground 1 2 Analog Output 5
Digital Ground 3 4 Axis 5 Encoder Phase A
Digital Ground 5 6 Axis 5 Encoder Phase B
Axis 5 Home Switch 7 8 Axis 5 Encoder Index
Trigger/Breakpoint 5 9 10 Axis 5 Forward Limit Switch
Axis 5 Inhibit 11 12 Axis 5 Reverse Limit Switch
Analog Output Ground 13 14 Analog Output 6
Digital Ground 15 16 Axis 6 Encoder Phase A
Digital Ground 17 18 Axis 6 Encoder Phase B
Axis 6 Home Switch 19 20 Axis 6 Encoder Index
Trigger/Breakpoint 6 21 22 Axis 6 Forward Limit Switch
Axis 6 Inhibit 23 24 Axis 6 Reverse Limit Switch
Analog Output Ground 25 26 Analog Output 7
Digital Ground 27 28 Axis 7 Encoder Phase A
Digital Ground 29 30 Axis 7 Encoder Phase B
Axis 7 Home Switch 31 32 Axis 7 Encoder Index
Trigger/Breakpoint 7 33 34 Axis 7 Forward Limit Switch
Axis 7 Inhibit 35 36 Axis 7 Reverse Limit Switch
Analog Output Ground 37 38 Analog Output 8
Digital Ground 39 40 Axis 8 Encoder Phase A
Digital Ground 41 42 Axis 8 Encoder Phase B
Axis 8 Home Switch 43 44 Axis 8 Encoder Index
Trigger/Breakpoint 8 45 46 Axis 8 Forward Limit Switch
Axis 8 Inhibit 47 48 Axis 8 Reverse Limit Switch
Digital Ground 49 50 Host +5 V

Figure B-4. 50-Pin Servo Connector Pin Assignment (Axes 5–8)

C

Input/Output Reset States

This appendix lists the various states of the 7350 hardware during reset.

Table C-1. I/O States During Reset

Signal Names	Direction	During Reset			After Reset/Before Device Initialization		
		Mode	Polarity	State	Mode	Polarity	State
Motion I/O Connector							
Inhibit <1..8>	Output	Open collector	Active low	Active	Open collector	Active low	Active
Breakpoint <1..8>	Output	Totem pole	Active low	Inactive	Totem pole	Active low	Inactive
Step <1..8>	Output	Totem pole	Active low	Inactive	Totem pole	Active low	Inactive
Direction <1..8>	Output	Totem pole	Active low	Inactive	Totem pole	Active low	Inactive
Digital I/O Connector							
Digital I/O Ports <1..8>	Input	—	Active low	Pulled up if DPULL left floating	—	Active low	Pulled up if DPULL left floating

D

Technical Support and Professional Services

Visit the following sections of the National Instruments Web site at ni.com for technical support and professional services:

- **Support**—Online technical support resources include the following:
  - **Self-Help Resources**—For immediate answers and solutions, visit our extensive library of technical support resources available in English, Japanese, and Spanish at ni.com/support. These resources are available for most products at no cost to registered users and include software drivers and updates, a KnowledgeBase, product manuals, step-by-step troubleshooting wizards, conformity documentation, example code, tutorials and application notes, instrument drivers, discussion forums, a measurement glossary, and so on.
  - **Assisted Support Options**—Contact NI engineers and other measurement and automation professionals by visiting ni.com/support. Our online system helps you define your question and connects you to the experts by phone, discussion forum, or email.
- **Training**—Visit ni.com/custed for self-paced tutorials, videos, and interactive CDs. You also can register for instructor-led, hands-on courses at locations around the world.
- **System Integration**—If you have time constraints, limited in-house technical resources, or other project challenges, NI Alliance Program members can help. To learn more, call your local NI office or visit ni.com/alliance.
- **Declaration of Conformity (DoC)**—A DoC is our claim of compliance with the Council of the European Communities using the manufacturer's declaration of conformity. This system affords the user protection for electronic compatibility (EMC) and product safety. You can obtain the DoC for your product by visiting ni.com/hardref.nsf.

- **Calibration Certificate**—If your product supports calibration, you can obtain the calibration certificate for your product at `ni.com/calibration`.

If you searched `ni.com` and could not find the answers you need, contact your local office or NI corporate headquarters. Phone numbers for our worldwide offices are listed at the front of this manual. You also can visit the Worldwide Offices section of `ni.com/niglobal` to access the branch office Web sites, which provide up-to-date contact information, support phone numbers, email addresses, and current events.

Glossary

Symbol	Prefix	Value
n	nano	10^{-9}
µ	micro	10^{-6}
m	milli	10^{-3}
k	kilo	10^{3}
M	mega	10^{6}

Numbers/Symbols

°	degrees
/	per
%	percent
±	plus or minus
+	positive of, or plus
–	negative of, or minus
Ω	ohm
+5 V	+5 VDC source signal

A

A	amperes
A/D	analog-to-digital
absolute mode	treat the target position loaded as position relative to zero (0) while making a move

absolute position	position relative to zero
acceleration/ deceleration	a measurement of the change in velocity as a function of time. Acceleration and deceleration describes the period when velocity is changing from one value to another.
active-high	a signal is active when its value is high (1)
active-low	a signal is active when its value is low (0)
ADC	analog-to-digital converter
address	character code that identifies a specific location (or series of locations) in memory or on a host PC bus system
amplifier	the drive that delivers power to operate the motor in response to control signals. In general, the amplifier is designed to operate with a particular motor type. For example, you cannot use a stepper drive to operate a DC brush motor.
Analog Input <1..8>	16-bit analog ADC input
Analog Output <1..8>	DAC voltage output
API	application programming interface
axis	unit that controls a motor or any similar motion or control device
Axis <1..8> Forward Limit Input	axis 1 through 8 forward limit switch
Axis <1..8> Home Input	axis 1 through 8 home input
Axis <1..8> $\overline{\text{Inhibit}}$	axis 1 through 8 inhibit output
Axis <1..8> Reverse Limit Input	axis 1 through 8 reverse limit input

B

b	bit—one binary digit, either 0 or 1
base address	memory address that serves as the starting address for programmable or I/O bus registers. All other addresses are located by adding to the base address.
binary	a number system with a base of 2
buffer	temporary storage for acquired or generated data (software)
bus	the group of conductors that interconnect individual circuitry in a computer. Typically, a bus is the expansion vehicle to which I/O or other devices are connected.
byte	eight related bits of data, an eight-bit binary number. Also used to denote the amount of memory required to store one byte of data.

C

CCW	counter-clockwise—implies direction of rotation of the motor
closed-loop	a motion system that uses a feedback device to provide position and velocity data for status reporting and accurately controlling position and velocity
common	reference signal for digital I/O
CPU	central processing unit
crosstalk	an unwanted signal on one channel due to an input on a different channel
CSR	Communications Status Register
CW	clockwise—implies direction of motor rotation

D

DAC	Digital-to-Analog Converter
DAQ	Data Acquisition

DC	direct current
dedicated	assigned to a particular function
DGND	digital ground signal
digital I/O port	a group of digital input/output signals
DIP	dual inline package
DLL	dynamic link library—provides the API for the motion control boards
drive	electronic signal amplifier that converts motor control command signals into higher-voltage signals suitable for driving motors
drivers	software that communicates commands to control a specific motion control board
DSP	Digital Signal Processor

E

encoder	a device that translates mechanical motion into electrical signals; used for monitoring position or velocity in a closed-loop system
encoder resolution	the number of encoder lines between consecutive encoder indexes (marker or Z-bit). If the encoder does not have an index output the encoder resolution can be referred to as lines per revolution.

F

F	Farad
FIFO	First-In, First-Out
filtering	a type of signal conditioning that filters unwanted signals from the signal being measured
filter parameters	indicates the control loop parameter gains (PID gains) for a given axis
flash ROM	a type of electrically reprogrammable read-only memory

following error trip point	the difference between the instantaneous commanded trajectory position and the feedback position
FPGA	Field Programmable Gate Array
freewheel	the condition of a motor when power is de-energized and the motor shaft is free to turn with only frictional forces to impede it
full-step	full-step mode of a stepper motor—for a two phase motor this is done by energizing both windings or phases simultaneously

G

Gnd	ground
GND	ground

H

half-step	mode of a stepper motor—for a two phase motor this is done by alternately energizing two windings and then only one. In half step mode, alternate steps are strong and weak but there is significant improvement in low-speed smoothness over the full-step mode.
hex	hexadecimal
home switch (input)	a physical position determined by the mechanical system or designer as the reference location for system initialization. Frequently, the home position is also regarded as the zero position in an absolute position frame of reference.
host computer	computer into which the motion control board is plugged

I

I/O	input/output—the transfer of data to and from a computer system involving communications channels, operator interface devices, and/or motion control interfaces
ID	identification
in.	inches

index	marker between consecutive encoder revolutions
inverting	the polarity of a switch (limit switch, home switch, and so on) in *active* state. If these switches are active-low they are said to have inverting polarity.
IRQ	interrupt request

K

k	kilo—the standard metric prefix for 1,000, or 10^3, used with units of measure such as volts, hertz, and meters
K	kilo—the prefix for 1,024, or 2^{10}, used with B in quantifying data or computer memory

L

LIFO	Last-In, First-Out
limit switch/ end-of-travel position (input)	sensors that alert the control electronics that physical end of travel is being approached and that the motion should stop

M

m	meters
MCS	Move Complete Status
microstep	The proportional control of energy in the coils of a Stepper Motor that allow the motor to move to or stop at locations other than the fixed magnetic/mechanical pole positions determined by the motor specifications. This capability facilitates the subdivision of full mechanical steps on a stepper motor into finer microstep locations that greatly smooth motor running operation and increase the resolution or number of discrete positions that a stepper motor can attain in each revolution.
modulo position	treat the position as if it is within the range of total quadrature counts per revolution for an axis

N

noise	an undesirable electrical signal—noise comes from external sources such as the AC power line, motors, generators, transformers, fluorescent lights, soldering irons, CRT displays, computers, electrical storms, welders, radio transmitters, and internal sources such as semiconductors, resistors, and capacitors. Noise corrupts signals you are trying to send or receive.
noninverting	the polarity of a limit switch, home switch, and so on, in *active* state. If these switches are active-high, they are said to have non-inverting polarity.

O

open collector	a method of output capable of sinking current, but not sourcing current
open-loop	refers to a motion control system where no external sensors (feedback devices) are used to provide position or velocity correction signals

P

PCI	Peripheral Component Interconnect—a high-performance expansion bus architecture originally developed by Intel to replace ISA and EISA. PCI is achieving widespread acceptance as a standard for PCs and workstations; it offers a theoretical maximum transfer rate of 132 MB/s.
PID	proportional-integral-derivative control loop
PIVff	proportional-integral-velocity feed forward
port	(1) a communications connection on a computer or a remote controller; (2) a digital port, consisting of eight lines of digital input and/or output
position breakpoint	position breakpoint for an encoder can be set in absolute or relative quadrature counts. When the encoder reaches a position breakpoint, the associated breakpoint output immediately transitions.
power cycling	turning the host computer off and then back on, which causes a reset of the motion control board

PWM	Pulse Width Modulation—a method of controlling the average current in a motor phase winding by varying the on-time (duty cycle) of transistor switches
PXI	PCI eXtensions for Instrumentation

Q

quadrature counts	the encoder line resolution multiplied by four

R

RAM	random-access memory
relative breakpoint	sets the position breakpoint for an encoder in relative quadrature counts
relative position	destination or target position for motion specified with respect to the current location regardless of its value
relative position mode	position relative to current position
ribbon cable	a flat cable in which the conductors are side by side
RPM	revolutions per minute—units for velocity
RPSPS or RPS/S	revolutions per second squared—units for acceleration and deceleration
RTR	Ready to Receive

S

s	seconds
servo	specifies an axis that controls a servo motor
sinusoidal commutation	a method of controlling current in the windings of a brushless servo motor by using the pattern of a sine wave to shape the smooth delivery of current to three motor inputs, each 120° out of phase from the next
stepper	specifies an axis that controls a stepper motor

stepper <1..8> Dir (CCW)	direction output or counter-clockwise direction control
stepper <1..8> Step (CW)	stepper pulse output or clockwise direction control

T

toggle	changing state from high to low, back to high, and so on
torque	force tending to produce rotation
totem pole	a method of output capable of sinking and sourcing current
trapezoidal profile	a typical motion trajectory, where a motor accelerates up to the programmed velocity using the programmed acceleration, traverses at the programmed velocity, then decelerates at the programmed acceleration to the target position
trigger	any event that causes or starts some form of data capture
TTL	transistor-transistor logic

V

V	volts
V_{CC}	positive voltage supply
velocity mode	move the axis continuously at a specified velocity

W

watchdog	a timer task that shuts down (resets) the motion control board if any serious error occurs
word	the standard number of bits that a processor or memory manipulates at one time, typically 8-bit, 16-bit, or 32-bit

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